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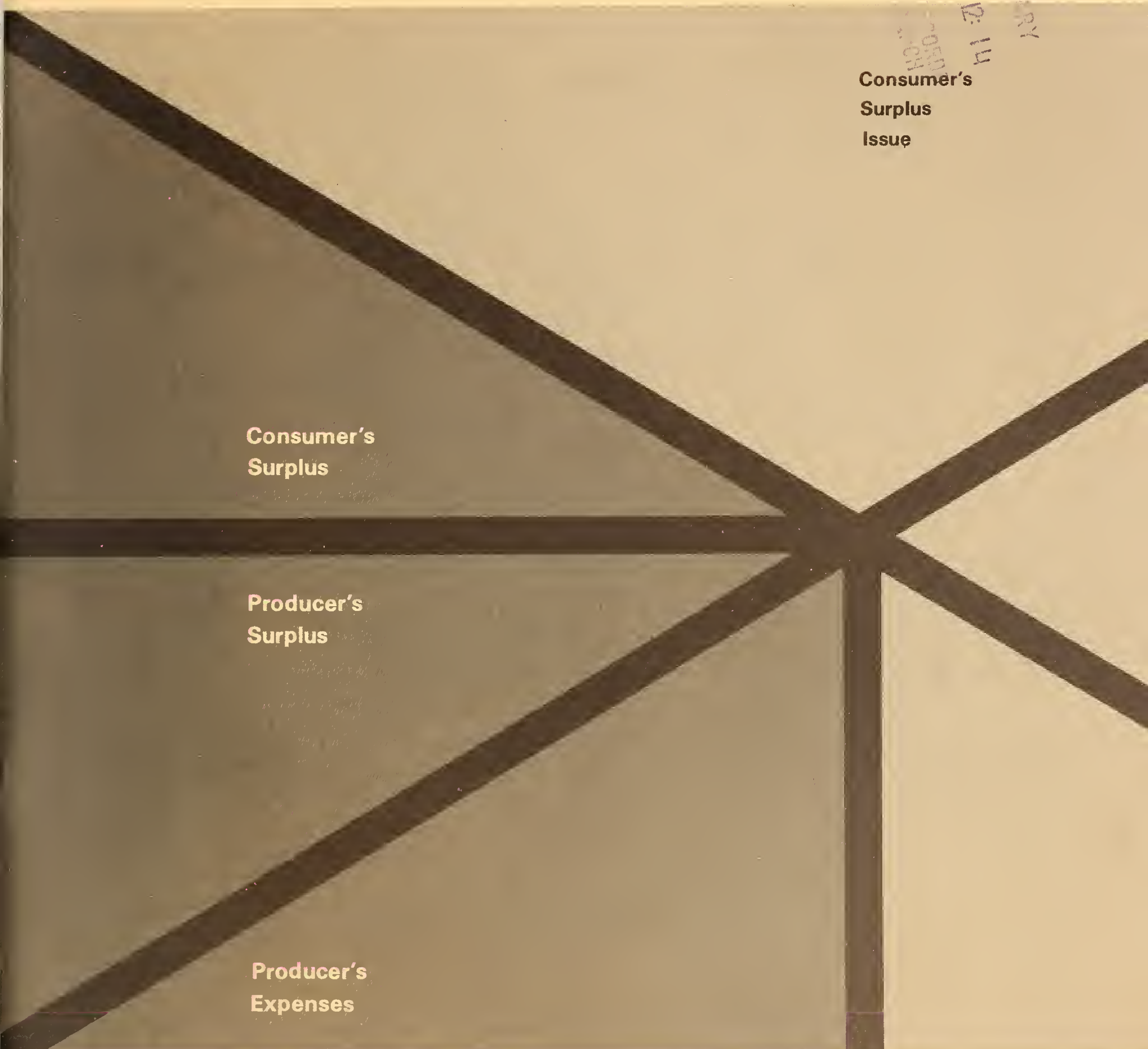

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IN THIS ISSUE

"The age of chivalry is gone," lamented Edmund Burke on theFrench Revolution then in progress. "The age of sophisters, economists, and calculators has succeeded. The glory of Europe is extinguished forever." The main point Burke sought to make is not of concern to the subject of this Journal, but a side-issue is: The phrase: "sophisters, economists, and calculators" carries a connotation which places Burke squarely in opposition to the subsequent emphasis in economics on theory, mathematics, and statistics. Several sophisters, calculators, and economists were born into the age succeeding the French Revolution, some of whom were trained in the mathematical methods of Newton and Leibniz. Among them was Dupuit, who published in 1844 his method for determining what Marshall later called consumer's surplus. Dupuit applied his ideas to problems of public policy. His ideas were lost for a while, along with other econometric ideas of W. F. Lloyd, Gossen, Cournot, and Verri. Jenkins independently redeveloped the idea of consumer's surplus in 1871. But the notion didn't enter the mainstream of economic thought until Marshall put it there in 1890.

In our first article, Mann traces the history of the idea of consumer's surplus and reviews its use in the literature of agricultural economics. Easter and Norton illustrate in the second article how the concept has been used to appraise the social value from corn and soybean research in the land-grant universities. Each of these authors applies the concept pretty much the way Dupuit and Jenkins intended.

The third article's authors take a different tack. They use the idea of consumer's surplus as a gimmick to trick a computer into providing the perfectly competitive equilibrium solution to a quadratic programming problem, an idea suggested to us by Samuelson in 1952.

Each of these articles is written by persons who believe in the usefulness of the idea of consumer's surplus, although Mann's article points to a few of the weaknesses in the concept. Readers may have their own opinions as to whether the age of sophisters, economists, and calculators, which uses concepts such as consumer's surplus to guide public policy, is to be cheered or lamented.

CLARK EDWARDS

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The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director, Office of Management and Budget, through February 28, 1980.

In Earlier Issues

Science is defined as " a continuing process of problem-solving in order to give man a better control over his experience." . . . A more widespread understanding of this pragmatic conception of science is sorely needed and the late Professor (Leonard A.) Salter rendered a real service in writing his chapter on the subject. (Salter concludes) . . . that research workers are in doubt as to what to do to get research results and make contribution to the solution of land economic problems. . . . Yet it is a question whether the 'doubts and confusions' are as uniform throughout the whole field of rural social science as Professor Salter's conclusions suggest. . . . As a matter of fact, . . . evidence indicates that many research workers are still proceeding in blissful ignorance of any necessity for doubt and uncertainty. In many areas equilibrium economics is still enthroned, and its practitioners announce their conclusions with all the certainty and dogmatism of a revealed religion.

"Review of: *A Critical Review of Research in Land Economics* (Leonard A. Salter, Jr.)" by Bushrod W. Allin. AER, Vol. I, No. 3, July 1949, pp. 98-99.

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TECHNIQUES TO MEASURE SOCIAL BENEFITS AND COSTS IN AGRICULTURE: A SURVEY

By Jitendar S. Mann

INTRODUCTION

In the last few years, great interest has been shown in evaluating the social benefits and costs of various public policies and programs. The cost-benefit technique has been used extensively in the evaluation of specific projects, such as those on river basins. The recent trend has been to measure changes in consumer's and producer's surplus associated with a specific program and to compare with program costs the benefits thus computed. A well-known example is Hayami and Peterson's study of the Statistical Reporting Service's crop forecasting (*41*).[1] The technique has been used extensively by Harberger (*37, 39*), particularly for measuring the effect of taxes.

Abstract: Development is traced of the concepts of consumer's and producer's surplus, and the uses and limitations of these concepts for public policy analysis are examined. The applications to price stabilization and policy programs are surveyed. The use of decision theory as an alternative to measurement of surplus is also examined.
Keywords: Consumer's surplus, producer's surplus, stabilization, policy analysis, decision theory.

In this article, I survey techniques used to measure social benefits and costs.[2] I also examine existing controversies as to the theoretical validity of the techniques. A brief history of the concept of surplus appears first, in the following section. An earlier survey of consumer's and producer's surplus is that by Currie (*21*.) The focus of my survey is the use of consumer's and producer's surplus. The more traditional types of cost-benefit analysis is treated extensively by Prest and Turvey (*77*), Krutilla (*57*), Lesourne (*59*), and Mishan (*70*).

[1] Italicized numbers in parentheses refer to items in References at the end of this article.

[2] This survey is by no means exhaustive. The selection of studies included in the discussion is influenced by the author's biases.

THE CONCEPT OF SURPLUS

The idea of measuring social benefits was first proposed by Dupuit (*27*) in 1844 and developed further by Hotelling (*48*). Without recognizing the theoretical difficulties in measuring utility, Dupuit (*27*) distinguished between total and marginal utility. An engineer by training, he was trying to determine criteria for the social value of collective goods such as roads, canals, and bridges. He argued that the value of a social good is greater than the price actually paid, that most people would be willing to pay more than they actually do. He measured the total benefit by the aggregate of maximum prices that would be paid for successive units of the commodity. The difference between this total benefit and the total cost of the product to the consumer he called "Consumer's Surplus". It was measured as the area under the demand curve and above the price line. Dupuit considered the effect of an increase in tax on a commodity, concluding that the loss of utility associated with a heavier tax increases as the square of the tax. He recognized that the yield of a tax to Treasury is no measure of the loss to society. Dupuit neglected the dependence of surplus on the consumption of other goods and services, the problem of aggregation, and the difficulties of measuring utility.

Dupuit distinguished between total and marginal utility. . . . He argued that the value of a social good is greater than the price actually paid, that most people would be willing to pay more than they actually do. . . . The difference between this total benefit and the total cost of the product to the consumer he called "Consumer's Surplus."

Reiterating the ideas of Dupuit, Marshall based his concept of consumer's surplus on the principle of diminishing marginal utility of a commodity (*63*). According to him, "the excess of price which he [the consumer] would be willing to pay rather than go with-

out the thing, over that which he actually does pay, is the economic measure of this surplus satisfaction. It may be called consumer's surplus." This benefit is derived from a man's opportunities, from his environment, or "conjuncture." Marshall developed similar concepts for worker's surplus and saver's surplus. He recognized that the area under the demand curve and above the price line provided an unambiguous measure of consumer's surplus only if the marginal utility of money is constant. He also noted that the demand curve may be asymptotic to the price axis and that the area under the curve is infinite. (See also Samuelson, *80*).

Marshall discussed the effect of tax and subsidy on consumer's surplus. In recognition of the difficulty of measuring the area, he limited his applications to changes in surplus. Considering separately commodities produced under constant, diminishing, and increasing returns, he concluded that there is net social loss from subsidy to an industry producing under diminishing returns. For an industry with increasing returns, the decrease in consumer's surplus from a tax is greater than the revenue to Treasury. Thus there is a net loss in social welfare from a tax on an increasing returns industry. The desirability of subsidy to such an industry is based on the observation that the industry will otherwise operate at less than the optimum output. It will do so because, for decreasing cost, the price exceeds the marginal cost. A positive measure, such as a subsidy, is needed to push output toward the optimum level. Marshall concluded that "if therefore a given aggregate taxation was to be levied ruthlessly from any class it will cause less loss of consumers' surplus if levied on necessaries than if levied on comforts." Ironically, this would imply a tax on an industry which produces necessities of life (much of agriculture) and subsidization of increasing returns industries that produce luxuries.[3]

These ideas of Dupuit and Marshall were, as mentioned, developed further by Hotelling (*48*). He considered whether services of a public project (such as a railway) should be sold at a price high enough to cover total cost. He considered a set of *n* commodity demand functions, and a set of *n* marginal cost functions. Defining excess demand functions as the difference between the demand and cost functions, one measures the total net benefit by the line integral of that function. The integral is independent of the path of integration if certain integrability conditions are met. The same measure was established by Hotelling through the use of the ordinal indifference curves. He derived a fundamental theorem:

> If a person must pay a certain sum of money in taxes, his satisfaction will be greater if the levy is made directly on him as a fixed amount than if it is made through a system of excise taxes which he can to some extent avoid by rearranging his production and consumption.

[3] For a different interpretation of Marshall's ideas on increasing returns, see Young (*105*).

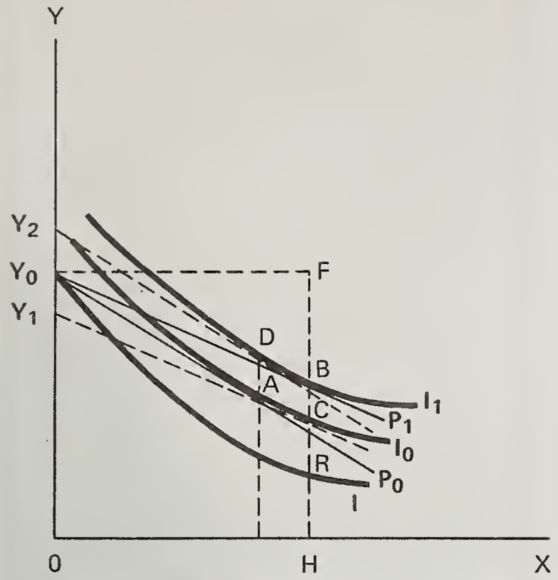
Boulding discussed the elementary concepts of consumer's and producer's surplus using demand-supply curves and also indifference curves (*12*). He pointed out the difference in the measures when one drops the assumption of constant marginal rate of substitution between the commodity and money. Hicks showed what happens in this case: "What ceases to hold is true equivalence between the consumer's surplus and triangle [under the demand curve] and a correction has to be introduced to overcome the discrepancy (*44*).

The earlier analyses are based on the condition that individual preferences can be added into community preferences. This possibility requires the assumption that all persons have identical, homothetic preferences, and the implication is that the marginal utility of income is the same for persons at all income levels. For an examination of implications of these assumptions about marginal utility, see Samuelson (*80*.)

Hicks attempted to reformulate the concept of consumer's surplus by using indifference curves to overcome the objection to the measurability of utility. (*44*, *45*). Measuring income on the Y axis and the commodity on the X axis places the consumer with an initial income of Y_o (and no X) on indifference curve I (fig. 1). At a price given by the slope of Y_oP_1, he buys OH and moves to indifference curve I_1. He is willing to pay FR (in money) to stay on indifference curve I after the commodity is introduced. He has to pay FB for OH of X if the price is P_1. The difference, BR, is the consumer's surplus. This, however, does not allow for the variation in marginal utility of money. To meet this last criticism, Hicks introduced the concept of four types of surplus (*21*, *45*):

- Compensating variation is the amount of compensation that will leave the consumer in his initial welfare position following a price change, if he is free to buy any quantity of the commodity at a new price. It is the most that the consumer will pay for the privilege of buying at the new price. For a fall in price from P_o to P_1 in figure 1, the compensating variation is Y_oY_1.
- Compensating surplus is the amount of compensation that will leave the consumer in his initial welfare position following a change in price, if he is constrained to buy at the new price the quantity he would have bought without compensation. In figure 1, the compensating surplus equals BC.
- Equivalent variation, Y_oY_2 in figure 1, is the amount of compensation that will leave the consumer in his subsequent welfare position without a change in price, if he is free to buy any quantity at the old price. It is the most amount of money that the consumer must be paid so that he is as well off without the new price.
- Equivalent surplus is the amount of compensation that will leave him in his subsequent welfare position without a price change, if he is constrained to buy at the old price the quantity he would have bought at that price with no compensation. It is AD in figure 1.

FIGURE 1
Hick's Principle of Variation



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The problem in regard to sugar in the early years of the war was essentially one of shipping; in the later years it was one of production. Prices were held at the lowest level too long, for the value of the savings to consumers at high levels of prosperity was questionable when higher prices would have been more encouraging to producers than the uncertain and deoayed CCC programs. Great increases in production in Cuba returned a substantial profit, but the bulk of its crop was sold to us at a reasonable price. Many of the programs to encourage the production of domestic beets were of the category of too-little and too-late; domestic beet processors were worse off than any other branch in the industry in the 1943-45 period because of apparent lack of interest in their problems at official policy levels. Sugar rationing, despite its shortcomings, was the most successful of the food-rationing programs and, unlike rationing of other foods, was not removed until adequate supplies were available. Equitable distribution of sugar throughout the country was one of the outstanding achievements of the OPA—made possible through the wholehearted cooperation of the entire sugar industry which was subject to more rigid controls than any other industry.

"Review of: *Sugar and Its Wartime Controls, 1941-47* (Earl B. Wilson) by Maxwell I. Klayman. AER, Vol. I, No. 3, July 1949, p. 103.

These ideas are generalized to a simultaneous change in several prices by the use of Paasche and Laspeyres index numbers. When the income effect of a price change is zero, the above four measures give identical results. Note that the compensating variation for a rise in price is equal to the equivalent variation for an equal fall in price. Conversely, the compensating variation for a fall in price equals the equivalent variation for an equal rise in price.

Dissatisfaction among economists about the usefulness of consumer's surplus has brought outright condemnation by Samuelson (*79*) who remarks: "The subject is of historical and doctrinal interest, with a limited amount of appeal as a purely mathematical puzzle."[4] Graaff further points out the difficulty of applying the tool of consumer's surplus to finite, indivisible changes, the problem of redistribution of gains and losses, and the effect of proposed policy changes on prices (*33*). On the other hand, Harberger (*40*) makes an appeal to accept three postulates of applied welfare economics as a part of the traditional framework of analysis:

- The competitive demand price for a given unit measures the value of that unit to the demander;
- The competitive supply price for a given unit measures the value of that unit to the supplier;
- When evaluating the net benefits or costs of a given action, one should normally add the costs and benefits accruing to each member of the relevant group without regard to the individuals to whom they accrue.

However, Harberger also admits (*37*) that "workers in this field must be ready to content themselves with results that may be wrong by a factor of 2 or 3 in many cases." This is a very important statement which users of the analysis should remember.

Willig derived exact upper and lower limits in approximating the compensating and equivalent variation with consumer's surplus (*102*). The limits depend on the consumer's base income and income elasticity of demand. He shows that, for example, if the consumer's income elasticity of demand is 0.8 and the area under the demand curve between the old and new prices is 5 percent of income, then the compensating variation is within 2 percent of the surplus measured as area under the demand curve. This simply rewords Hotelling's observation that consumer's surplus "breaks down if the variations under consideration are too large a part of the total economy of the person." However, Willig did not consider the issue of aggregation from consumer's surplus to social benefit to the society.[5]

Mishan has expressed concern about the advisability

[4] Note, however, that Samuelson used the concept under the name of social payoff in (*81*).

[5] His concluding sentence is noteworthy. "At the level of the individual consumer, cost-benefit welfare analysis can be performed rigorously and unapologetically by means of consumer's surplus."

of measuring producer's surplus (*69*). He considers a person maximizing his utility function subject to the constraint that the sum of expenditures and earnings is zero (*66*). The person is considered to supply goods and services. He points out that here there is no income effect, and he uses the term "welfare effect." He suggests the concept of rent as economic surplus which should be measured as a compensating or an equivalent variation. Economic rent is a money measure of welfare change from a movement in factor prices.

Mishan further points out the importance of distinguishing between shortrun and longrun supply functions (*69*). The area above the supply curve measures producer's surplus only for a special type of supply curve; namely, one for a period during which output can be increased by adding to the fixed factor quantities of other factors which are imperfect substitutes but perfectly elastic in supply. When all the factors are variable, we cannot derive a producer's surplus from a supply curve. It is not clear whether the producer is an entrepreneur or the owner of factors of production. Mishan recommends that the ambiguity can be avoided by banishing the term "producer's surplus" and concentrating on economic rent as a measure of surplus. The issues raised by Mishan are faced by Peterson in his study of poultry research (*76*) and by Ayer and Schuh in their study of cotton research in Sao Paulo, Brazil (*5*). After analyzing economic surplus, Ayer and Schuh discuss the effect of research expenditures on capital, value of land and labor income.

Winch has shown that consumer's gain can be estimated within certain limits allowing for compensation in the sense of Hicks (*103*). The net gain or loss resulting from aggregation is a valid measure only if the society is indifferent to the redistribution of gains and losses.

As pointed out by Little (*61*, chapter 10), consumer's surplus is based on partial analysis only. It is assumed that no significant price change occurs elsewhere in the economy. This assumption is possible in the longrun only by assuming constant costs. Alternatively, the product under discussion may be independent of all other goods, using only a very small fraction of the available resources. Further price must be equal to marginal cost—pure competition—everywhere. Little concludes that consumer's surplus is a totally useless theoretical toy because it cannot provide a practical, objective criterion for public policy.

APPLICATIONS TO PRICE STABILIZATION

There has been a long debate on the effects of price instability and the social benefits and costs of stabilization programs. Waugh, assuming a negatively sloped, stable demand curve, studied the effect of shifts in supply (*98*). Total consumer's surplus from a series of variable prices will be greater than if the price were stabilized at the arithmetic average. He stated a theorem on the benefits of price instability:

> Let the price of any commodity or service be P_1 in one period of time and P_2 in another equal period. If these prices are unequal, every individual consumer of the commodity or service will enjoy a greater average consumer's surplus in the two periods than if the price were stabilized at the arithmetic mean, $P_o = \frac{1}{2}(P_1 + P_2)$.

He compared the constant price P_o with the price P_1 in one period and P_2 in the other. When the price is OM, the loss in consumer's surplus (compared with the constant price OL which is average of OM and OG) is MNJL (fig. 2). When the price is OG, the gain in consumers' surplus is LJEG. Evidently, there is a net gain compared with behavior in a stable price situation.

According to Waugh, the net gain in consumer's surplus from instability is the areas NQJ and JRE, assuming a linear demand curve. Over time, the net gain in consumers' surplus is approximately:

$$\tfrac{1}{2} \Sigma\, \delta_k \Delta_k$$

where δ_k is change in price, Δ_k the associated change in quantity, and k is a time index. The gain in consumer's surplus is approximately proportional to the square of the price variation.[6] A doubling of price variation quadruples the net gain in consumer's surplus.

Commenting on Waugh's theorem, Howell raised several objections (*49*). He pointed out that Waugh had not shown that the specified price (arithmetic mean) was the only one, or the most feasible one, at which prices may be stabilized. He demonstrated that "if prices were stabilized at or below the weighted average of P_1 and P_2, every individual consumer of the commodity or service would enjoy a larger average consumer's surplus than if the prices were not stabilized at all." In determining the feasibility of price stabilization, one should also consider the effects on producers' income and quantities consumed:

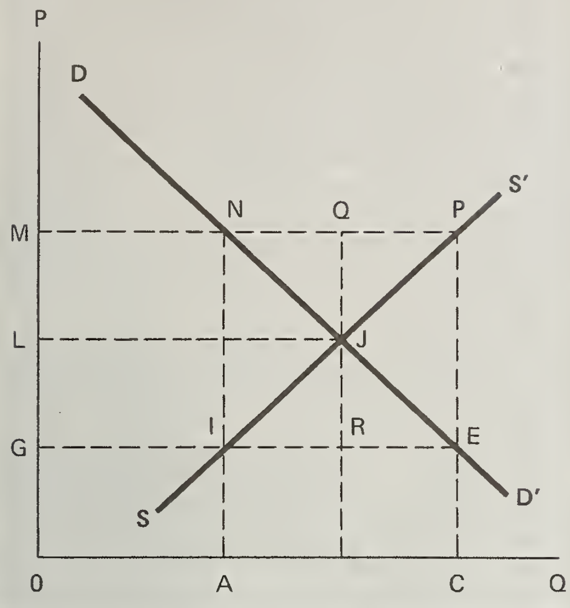
> Price stabilization operations may give results varying all the way from increases in average consumer's surplus, in gross income to producers, and in average quantity demanded to decreases in average consumer's surplus, in gross income to producers, and average quantity demanded, including various combinations of those results, depending upon the point at which prices are stabilized and upon the shape of the demand curve.

Howell also pointed out that, in measuring consumer's surplus, an assumption of constant marginal utility of money had been made.

Similar objections to Waugh's analysis were also raised by Lovasy (*49*). She stated that the Waugh theorem is correct only if demand is stable and if the

[6] This fact has been used by researchers to analyze the problem with quadratic programming.

FIGURE 2
Schematic Diagram of
Social Costs and Benefits



prices of different goods do not vary in constant ratio to one other.

Waugh replied by rewording his theorem (*49*):

> Let the price of any commodity or service in n equal periods of time be $P_1, P_2,—P_n$. Assuming that demand is stable and that the demand curve slopes downward to the right, stabilization of the price at or above the simple arithmetic mean $\frac{1}{n}(P_1 + \cdots + Pn)$, would reduce the consumer's surplus of each individual consumer, while stabilization of the price at or below the weighted mean, $\frac{P_1Q_1 + \cdots + P_nQ_n}{Q_1 + \cdots + Q_n}$, would increase the consumer's surplus of each individual consumer.

Unaware of Waugh's work, Oi enunciated a similar proposition for the producer: "Given a fixed expected value of price, P, the greater the variability of price about the expected value, the greater will be the expected profit" (*74*). He assumed that firms maximize shortrun profits during each period, and that the marginal cost curve of each firm is upward sloping throughout the relevant range. Given a convex profit function, it follows that the average of profits for varying price is greater than the profit at average price. Tisdell pointed out that the errors of price forecast by producers will lead to different results (*92*).

Samuelson stated a theorem in terms of the compensation principle and showed that Waugh's theorem is a special case (*82*). However, he demonstrated that, "in a closed system, when it goes from stable prices to unstable prices it must necessarily have those unstable prices average out to higher than the stable prices." Thus, he doubted the feasible application of Waugh's theorem, even as a special case.

Massell integrated the two approaches and considered sources of disturbance both in demand and supply (*64*). He showed the benefits of error elimination to consumers and producers. He assumed linear demand and supply curves and additive stochastic disturbances. Massell set up a model including supply and demand curves which incorporate continuously distributed random shifts:

$$S = \alpha p + x$$

$$D = - \beta p + y$$

where S = quantity supplied, D = quantity demanded, p = price, α and β are constants, and x and y are random variables with means Mx and My, variances σ_{xx} and σ_{yy}, and covariance equal to zero. The expected value of gains from stabilization of price at expected value are:

$$E(G_p) = \frac{(\alpha + 2\beta)\,\sigma_{xx} - \alpha\sigma_{yy}}{2\,(\alpha + \beta)^2}$$

In Earlier Issues

Early in that period of industrial growth (1865-1918) . . . (Henry C. Adams) had caught its meaning when he asserted that the central problem of economics "is properly to correlate public and private activity so as to preserve harmony and proportion between the various parts of organic society." . . . This history causes one to ponder the view that the English have held a monopoly on the development of economic theory; for men like Walker, Adams, Clark, Taussig, Davenport, and Mitchell, were exploring the unknown in as profound a sense as their British cousins. . . . pure competition theory was probably no more applicable to the nineteenth century than to the twentieth. . . . The emphasis on marginalism and other tools of analysis in the development of theory had the immediate effect at least of removing economic theory from the arena of economic action. . . . Economists cloistered in academies of higher learning were refining the theory of pure competition as the operators were engaged in organizing and reorganizing business firms into monopolistic combinations.

"Review of: *The Economic Mind in American Civilization* (Joseph Dorfman) by Willard W. Cochrane. AER, Vol. I, No. 3, July 1949, pp. 99-100.

$$E(G_c) = \frac{(2a + \beta)\,\sigma_{yy} - \beta\sigma_{xx}}{2\,(a + \beta)^2}$$

where G_p and G_c are given to producers and consumers. Total gain is

$$E(G) = \frac{\sigma_{yy} + \sigma_{xx}}{2\,(a + \beta)} = \left[\frac{a + \beta}{2}\right]\sigma_{pp}$$

where σ_{pp} is the variance of price. Massell made these conclusions:

- Producers lose (gain) from price stabilization if the price instability is due to random shifts in demand (supply). This is Oi's case which was criticized by Tisdell.
- Consumers lose (gain) from stable price if the price instability is due to random shifts in supply (demand).
- Where both demand and supply shift randomly, the gains to each group are indeterminate and depend upon the relative sizes of the variances and upon the slopes of the demand and supply curves.
- Provided neither the demand curve nor the supply curve is perfectly elastic, the total gains from stabilization are always positive, with gainers being able in principle to compensate the losers. With infinitely elastic functions, all gains tend to zero.

Massell recognized the problem of compensation by the gainers to the losers. However, he gave no operational plan for redistribution of benefits. Massell assumed that the commodity under discussion is a very small part of producer sales and consumer purchases so that the change in its price leaves the marginal utility of money unchanged. Turnovsky generalized the results by considering errors following a Markov process (*94*). He considered the case wherein supply decisions are based on price expectations of two types—adaptive and rational. Turnovsky's major conclusions appear below:

- The Oi's proposition that producers lose from price stabilization if price instability is due to demand fluctuations depends on how the expectations are generated and on the moving average properties of the error term.
- If the expectations are formed rationally, Oi's result holds, provided the errors in the demand function have positive or negative serial correlation.
- If the expectations are formed adaptively, Oi's proposition will not hold, unless the error terms in the demand function have high positive serial correlation.
- The Waugh proposition for consumers will hold under either form of expectation.
- Massell's result that producers and consumers gain from stabilization holds in both cases.
- Massell's quantitative results remain unchanged under rational expectations. Some differences result with adaptive expectations.

Analysis is based on the assumption that total welfare can be measured by the sum of producer's and consumer's surplus. Subotnik and Houck extended the analysis to problems when consumption is stabilized (*90*). Assuming rational expectations, they compared the benefits from stabilizing prices at their mean to those of stabilizing consumption and production at their means.

Most researchers ignored the so-called "middleman" when analyzing the distribution of gains and losses. Bieri and Schmitz examined the case in which monopolistic middleman would gain by destabilizing prices to producers (*9*). They considered a case of two time periods with demand and supply functions defined for each period. They also include a storage cost function in their model. Finally, they examined the case of a pure middleman who maximizes profit and the case of a producer marketing board which maximizes returns (including producer's surplus) to producers.

In another, later article, Massell examined the effects of a buffer stock on expected value and variance of producer's income (*65*). He considered an agricultural commodity with demand and supply curves:

$$D = -\beta p + y$$

$$S = x$$

where D = demand, S = supply, p = price and y and x are random variables. The stabilization program involves a transformation of the demand curve. Massell examines the effect of stabilization in two stages: (1) eliminating the stochastic term in the demand curve and (2) rotating the demand curve to increase its slope. He shows that stabilization increases expected value and decreases variance of producer's income. Thus he includes producer's risk aversion in his analysis. He analyzes the welfare implications of stabilization by using indifference curves.

While Massell's analysis was limited to a single market, Hueth and Schmitz examined internationally traded goods in a two-country, spatial price equilibrium model (*50*). They discussed separately the case of final product and an intermediate good which a country imports and uses in domestic production of final goods, some of which are also imported. An appropriate example is wool, which has been examined by Dardis (*22*) and Dardis and Dennison (*24*). In the Hueth-Schmitz model, the source of price instability is shifts in demand and supply in the foreign market. The instability is carried on to the domestic market which adjusts by movements along the demand and supply curves. Hueth and Schmitz showed that both producers and consumers prefer price instability to price stability. This conclusion depends on the fact that price instability is generated by movements along the demand and supply schedules.

The above studies of Waugh-Oi-Massell and their followers assume linear demand and supply curves with additive disturbances. Turnovsky developed a general model including nonlinear demand and supply functions with multiplicative disturbances (*95*). Theoretical justifi-

cation for nonlinear functions with multiplicative errors is given by deriving a supply curve from a homogeneous production function and a demand curve from an indirect utility function. An important conclusion is that the desirability of price stabilization (increase in social welfare) of either producers or consumers does not depend on the source of price instability.

In most studies, the analysts have considered random fluctuations in demand and supply and the effect of various stabilization programs on equilibrium prices and quantities. Anderson and Riley consider welfare implications of price uncertainty for a country which specializes in production of export goods (*3*). They show that social welfare for such a country is less with fluctuating prices compared with fixed prices.

APPLICATIONS TO POLICY AND PROGRAMS[7]

The early attempts at measuring social returns compared the cost with additional output. Griliches compared the cost of research on hybrid corn with the value of increased production from the adoption of hybrid corn seed (*34*). Evenson tried to assess the benefits from research by using expenditures on research and extension in an aggregate production function (*28*). Earlier, Waugh had tried to show the effect of market prorates on social welfare (*97*). He was criticized by Stigler for being oblivious to the problem of interpersonal comparisons of utility (*89*). Following Griliches and using economic surplus, Peterson studied the benefits of poultry research, and he found that the improved techniques resulting from research bring about a shift in the supply curve. He developed an approximate method for measuring the surplus from the shift in supply (*76*).

The social costs and benefits of U.S. farm programs were measured by Nerlove (*73*, pp. 222-235) and Wallace (*96*). Nerlove used his estimates of supply elasticities to measure welfare cost of alternative price support programs. He considered three types of programs: (1) The Government sets a support price above the equilibrium price and purchases and destroys all excess crop; (2) the support price is set above the equilibrium price; farmers are allowed to sell all they produce in the open market and the Government pays a per unit subsidy equal to the difference between support price and the market price; (3) the output is restricted by direct controls to bring about the desired price.

Nerlove assumes that the supply curve is the marginal social cost of the resources used to produce the commodity and that the demand curve is the marginal value of the commodity to the community (fig. 2). He assumes that each program aims to attain a price OM. Welfare loss is taken as the difference between Government expenditures and the net benefits to consumers and producers. The net losses of the three programs are given by the areas ANJPC, JPE, and NJI, respectively. Nerlove concludes that programs of types 2 or 3 can never involve a social loss of welfare greater than that of program 1. He derived formulas for net loss in terms of the proportion by which the support price exceeds the equilibrium price (x), and the elasticities of demand (η) and supply (ϵ). The three formulas are:[8]

$$L_1 = x(1 + x)\,(\eta + \epsilon) - \tfrac{1}{2}x^2\,(\eta + \epsilon)$$

$$L_2 = \tfrac{1}{2}x^2\epsilon\left(1 + \frac{\epsilon}{\eta}\right)$$

$$L_3 = \tfrac{1}{2}x^2\eta\left(1 + \frac{\eta}{\epsilon}\right)$$

Nerlove stated that the relative magnitude of the loss of under types 2 and 3 programs will depend on the difference between the support price and the equilibrium price and upon the elasticities of demand and supply. Wallace demonstrated that, for a given support price (*96*):

$$\text{NSL (3)} \gtreqless \text{NSL (2)}$$

$$\text{as } \eta \gtreqless \epsilon$$

Wallace also analyzed the effects of output restriction through control of input (for example, acreage allotments). He had two premises: (1) the total area under the demand curve to the left of a given quantity represents total utility for that quantity and (2) the supply curve reflects opportunity costs of variable resources used to produce each quantity. The type 3 program is called the Cochrane Proposal by Wallace. Wallace's formula in premise 2 (*96*, p, 582) is identical to Nerlove's formula for L_3 except that Nerlove measures the loss as percent of the value of the crop. In the type 2 program, called the Brannan Plan, Wallace's formula is Nerlove's formula for L_2.

The same framework of analysis was used by Johnson to estimate the net social cost of the tobacco program (*53*). He took into account U.S. monopoly power in the world market. Johnson recognizes the problem of the second-best solution in estimating the social cost of the tobacco program (*53*). He estimates three types of costs for the flue-cured and burley tobacco acreage allotment program:

[7] Not included here are studies of restrictions on international trade. These have been summarized in an article by Corden (*20*).

[8] The absolute values of elasticities are considered in this discussion.

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- The social cost is estimated by the "triangle Method:"

$$SC = \frac{1}{2} p_0 q_0 \eta \tau^2 \left(1 + \frac{\eta}{\epsilon}\right)$$

where τ is the percentage increase in price over the free market equilibrium price.

- The monopoly rent gained from foreigners through export demand is estimated as the price increase times the quantity exported.
- Efficiency loss in producer surplus due to input (land) restriction is estimated as follows: He assumes a Cobb-Douglas production function with a supply curve $Q=AP^{\epsilon}$, and a demand function $Q=BP^{-\eta}$. Given price increases equal to τ, the efficiency loss is calculated as:

$$\frac{\epsilon}{1+\epsilon} p_0 q_0 \left[(1+\tau)^{1-\eta} - (1+\tau)^{-\eta} \frac{(\epsilon+1)}{\epsilon}\right]$$

Welch studies supply controls with marketable quotas. He introduced uncertainly into his analysis. Harberger discussed what he called "the economics of the nth best" (*38*). He was concerned with measuring the social cost associated with the economy being in any nonoptimal position. He called the social cost "deadweight loss."

Hayami and Peterson developed an analytical framework for social returns to Government expenditure on statistical reporting of agricultural commodities (*41*). Two models are considered: inventory adjustment and production adjustment. The inventory adjustment model includes cases wherein production cannot be changed in response to output forecasts and reactions to forecasts occur as stock adjustments. Assuming linear demand, the net welfare loss due to symmetric errors in forecasts is estimated as:

$$\Delta NB = \epsilon^2 pq \frac{1}{a}$$

where q is the true quantity of production, p is the equilibrium price, ϵ is the error in quantity of products as a proportion of the true production, and a the price elasticity of demand.

In the production adjustment models the producers adjust output in response to changes in price expectations. The net social cost of error in production reporting in this case:

$$\Delta NB = \frac{1}{2} \epsilon^2 pq \left(\frac{\beta}{a2} + \frac{\beta 2}{a^3}\right)$$

where β is the elasticity of supply and other symbols are as defined above.

Bullock has developed a model including a cost of storage function along with the demand for storage stocks (*13*). According to Bullock, sheer magnitude of the forecast error need not be of concern—reducing the average forecast error will not generate social benefits (which was the Hayami-Peterson assumption). The key variable is how the frequency of forecasts has changed in the process.

STUDIES USING DECISION THEORY

The studies discussed above are based on the classical principles of welfare economics. Another approach is to use statistical decision theory. A survey of decision theory with applications to agriculture is given in Dillon (*26*). More analysts have used the consumer-producer surplus approach than the decision theory method; however, the latter is receiving more attention in program evaluation. Lave studied the value of better weather information to the raisin industry (*58*). A grower can use it in making the following decisions: (1) how high a yield to plan, (2) when to pick the grapes, and (3) whether to sell for crushing. The first task is to optimize the yield decision by under- or fully cropping. Once this decision has been made, growers have three actions open: (a) pick grapes 21 days before the first expected rainfall, (b) sell for crushing at any time, and (c) pick the grapes when ripe and pay no attention to the weather. A payoff matrix is obtained given the probability of rain during any of the six consecutive 10-day periods, the first starting September 1.

Byerlee and Anderson developed a method for assessing the monetary value of additional information in the response process (*17*). Three classes of inputs are considered: controlled, uncontrolled and known at the time of the decision, and uncontrolled and not known at the time of the decision. They illustrate the analysis by using a rainfall predictor in determining optimal application of nitrogen to wheat. The response function includes several factors: applied nitrogen, growing season rainfall, soil moisture, total soil nitrogen, and initial soil nitrate. The function includes interaction between nitrogen and rainfall: interaction is a necessary condition for additional information on rainfall to have significant economic value. A prior distribution for growing season rainfall is developed from historic data. A matrix of conditional probabilities of growing season rainfall, given the annual rainfall, was developed from this matrix and the posterior probabilities of growing season rainfall calculated. The expected profit is calculated from the posterior distribution. The rainfall predictions for six different intervals are used to decide the optimum level of nitrogen. The difference between expected profits with and without rainfall predictions is the value of the information.

Baquet, Halter, and Conklin measured the economic value of frost forecasts to pear orchardists in Jackson County, Oregon, using a Bayesian decisionmaking technique (*7*). The decision is whether to turn on the heaters to protect the pear orchards against frost. The temperature forecast during the frost season is provided by the U.S. Weather Service. The conditional probabilities of forecast temperatures and recorded temperatures are developed from historic data. Using historic prior probabilities of nighttime low temperature readings, the posterior probabilities are developed. A utility function is estimated for each of the eight orchardists studied. The utility payoff matrix is multiplied by the posterior

probabilities to obtain the optimal action for each forecast. The value of forecasts is the difference between the monetary outcome of Bayes action and the monetary outcome of the optimal prior actions.

These studies using decision theory approach are microanalyses of a few producers. Generalization of the technique to aggregate studies provides a challenge for further work.

A CRITIQUE AND CONCLUSIONS

Most studies of measurement of social costs and benefits assume a perfectly competitive system with perfect knowledge and perfect mobility. It is well known that a perfectly competitive system leads to Pareto optimal social welfare. However, in practice there is no such thing as perfect competition. Once additional restrictions—lack of perfect knowledge—are allowed for, Pareto optimum is not attainable or desirable (Lipsey and Lancaster, *60*). As a matter of fact, if the system were perfectly competitive, we would not need some programs, such as crop forecasting. Once imperfections are admitted, it follows that the removal of any one constraint may affect welfare either by raising, lowering, or leaving it unchanged (Lipsey and Lancaster, p. 12). Commenting on the Oi's finding that "price instability is a virtue and not a vice," Tisdell showed the importance of the two assumptions of perfect mobility and perfect knowledge (*92*). Perfect mobility implies that producers can readily adjust output to changed price. Perfect knowledge implies that they can accurately forecast the price. In the absence of perfect forecasts and perfect adjustment, Tisdell derived the opposite of Oi's results. The extension of the analysis to a noncompetitive economy will be a useful topic for research.

So long as one's analysis is partial equilibrium, it is of limited validity. The study of one particular program or commodity does not concern itself with global welfare and, according to Lipsey and Lancaster, "piecemeal welfare economics" is futile (p. 17). Hushak, who recognized the interaction between one crop and others took a step in the right direction (*51*). Most analysts studying social benefits and costs have used the classical welfare economic tools of consumer's and producer's surplus without worrying about their theoretical validity. These researchers only point out the high social benefit-cost ratio of particular proposals. The general problem of ranking all the programs under consideration in a general equilibrium system has not been successfully attempted.

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In Earlier Issues

As the years roll by we are able to reflect on the influences in the world of agricultural economics that grew out of Professor [Benjamin Horace] Hibbard's teaching at the University of Wisconsin. He was not the kind of professor who taught a doctrine and expected the students to remember everything that was in his lectures or the textbook. Rather, he was a leader in thought who developed a philosophic understanding of the economic phenomena in agriculture. He was a humanist in the sense that human welfare and human behavior were always of foremost interest to him.

Professor Hibbard . . . has kept out [of his book] quantitative data and . . . theoretical points which would have greatly expanded the scope of the book, thereby limiting the readership and wide use which it deserves . . .

M. L. Wilson
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April 1949

POTENTIAL RETURNS FROM INCREASED RESEARCH BUDGET FOR THE LAND GRANT UNIVERSITIES

By K. William Easter and George W. Norton*

Investment in U.S. agricultural research is substantial and it continues to expand. Numerous studies have shown that past agricultural research expenditures have high rates of return. However, private investment in agricultural research is restricted since many of the research benefits cannot be captured by a private firm.[1] Thus, the public sector must do much of the basic agricultural research. Among the key institutions in this public research capacity, including dissemination of the results, are the agricultural experiment stations and the extension services in the land grant universities.

Abstract: With the growing competition for Federal dollars, the land grant universities were asked to justify their budget to the Congress and the Office of Management and Budget using benefit-cost analysis. The authors review previous studies of returns to agricultural research and present an analysis of corn and soybean research that formed part of these universities' 1978 budget request for Federal monies. New research to increase corn and soybean production would bring very high returns, and consumers would be the primary beneficiaries. The large acreage affected by the research was an important reason for these high returns. Consumers would benefit from lower prices and the resulting increase in consumer surplus. Keywords: Benefit-cost, consumer surplus, agricultural research, corn, soybeans.

As competition grows for both Federal and State budget funds, the land grant universities have been asked to provide projected rates of return or benefit-cost analyses of their research and extension budget requests. To help respond to such requests from the Office of Management and Budget (OMB) and the Congress, a Committee on Program Analysis for the USDA Budget was established in 1976 to begin to apply such analysis to budget requests from the agricultural experiment stations and the extension services. The analysis we present formed part of this committee's work and it was used to help justify these universities' 1978 USDA budget request to OMB.

We briefly review approaches used to assess returns to U.S. agricultural research and explain the usefulness of benefit-cost analysis in such evaluations. We then apply such analysis to the land grant universities federal budget requests for additional funds for corn and soybean research in the North-Central region.

REVIEW

The first major attempt at quantitative evaluation of agricultural research investments was conducted by T. W. Schultz (*16*).[2] He calculated the value of inputs saved in agriculture because of improved production techniques and compared this with the costs of research and development. His effort was followed by that of Griliches (*5*) who calculated the loss in consumer surplus that would occur if hybrid corn were to disappear. His analysis assumed that the adoption of hybrid corn shifted the supply curve of the product downward to the right. He estimated the returns in the two polar cases of perfectly elastic and perfectly inelastic supply elasticities. In each case, the area below the demand curve and between the original and the shifted supply curves constitutes the estimated amount of the returns.

Peterson (*15*) generalized Griliches' formula for estimating consumer surplus and applied it to poultry research. He calculated the case wherein supply is neither perfectly elastic nor perfectly inelastic and did not require a demand elasticity of one as Griliches' formulas did. Peterson says that the biggest problem with his and Griliches' method (which he refers to as the index number approach) is that of obtaining a measure of productivity gain that reflects only the output of research (*14*).

In another study (*6*) Griliches was perhaps the first to use an aggregate production function approach to estimate a marginal product of research. A marginal return is more useful than an average return to decisionmakers

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[1] However, for agricultural research such as seed and pesticide development, private firms can capture enough benefits and they contribute substantially to such research.

[2] Italicized numbers in parentheses refer to items in References at the end of this article.

studying the merits of new research projects. Evenson (*2*) also calculated a marginal product of aggregate agricultural research expenditures. In addition, he estimated that the returns over time first increased and then decreased and that the high point occurred after about 6 years.

Tweeten and Hines (*20*) employ a different approach in their study of the returns to aggregate agricultural research. They calculate how much lower the national income would be if the percentage of people on the farm remained the same as in 1910 and if the resulting additional farmers had the income of today's farmers instead of today's nonfarmers. They estimate the costs of public and private research, education, and Federal programs and calculate a benefit-cost ratio.

Fishel (*4*) describes a computerized model for collecting and processing information needed to evaluate research activities and to select an efficient allocation of resources. He stresses the importance of recognizing that there is a probability distribution around likely benefits from research. To obtain the information needed to arrive at a subjective probability distribution, scientists were asked to predict (1) the most likely outcome as well as high and low outcomes that would be exceeded only one-third of the time and (2) high and low outcomes that would be exceeded only in very exceptional circumstances. Application of the model required a fairly extensive set of surveys.

Bredahl and Peterson (*1*) look at the differences in rates of return to various kinds of agricultural research (cash crops, dairy, poultry, livestock) to determine if the overall rate of return could be increased by reallocating some research resources from the low to the relatively high return activities. They utilize aggregate agricultural production functions in which research is a separate independent variable to estimate the marginal products of research.

Another research evaluation procedure has been used involving various types of scoring models. These models do not provide quantitative estimates of benefits and costs but rank the research alternatives. The National Association of State Universities and Land Grant Colleges and USDA published in 1966 the results of a study of agricultural and forestry research programs in the United States (*22*). The study evaluated the strengths and weaknesses in the research program, identified future research problems, and recommended a level of public support for agricultural research for a 10-year period. A major result was the systematic classification of research areas. (A subsequent publication, (*23*), lays out the classification system in detail.) A simple scoring model was used to determine the extent to which each research priority area met certain criteria. Each specified criterion was weighted in terms of importance. This system was used to bring out facets of a problem that otherwise might have been overlooked, but it was not employed as a mathematical basis for allocating resources.

Another study which used a simple scoring scheme to rank research problem areas was done in Iowa to aid in the allocation of resources at the Iowa Experiment Station (*9, 11*). This study was one of the first, along with the Fishel study cited above, to give explicit consideration to the importance of the probabilities of success of a research project.

Shumway and McCracken (*19*) also focused on a set of numerical models for ranking recommended resource reallocations at the North Carolina Agricultural Experiment Station. The goal was to determine which research problem areas should be emphasized over the next 5 years. Various people scored the research program areas (RPA's) which were then ranked.

The majority of agricultural research evaluation studies have fallen, therefore, into three basic classes: (1) the study of returns to aggregate agricultural research; (2) the study of returns to research on individual commodities; and (3) the use of models which are designed to rank alternative research projects or problem areas within an individual agricultural experiment station or nationally. Most studies in the first two categories are oriented toward the past while those in the third are oriented toward evaluating research for the present or future.

As a practical matter, the Federal Government must evaluate experiment station requests for additional funding annually, and this evaluation must be completed in a short period of time. The classification scheme developed in the USDA-SAES study aids in delineating where funds might be used. Studies which have evaluated returns to past research do provide many valuable insights into the value of future research. However, there has been little quantitative *ex ante* estimation of returns to research.

Some have suggested that benefit-cost analysis can be used to provide this *ex ante* evaluation. Fedkiw and Hjort (*3*) believe that benefit-cost analysis can be a useful tool if sensitivity analysis is used and scientists are asked to provide an opinion on the probability of success of each project. The determination of a benefit-cost ratio can be made relatively quickly even without a computer. More skeptical about the adequacy of the methodology, Williamson (*24*) stresses that unless active support is obtained from the scientists, reliability of estimates will be seriously impaired. Peterson fears that widespread use of benefit-cost analysis could be very costly; some projects require more resources to evaluate than are in the project budget (*13*). Paulsen and Kaldor stress the importance of keeping the benefit-cost analysis simple (*11*).

The above comments suggest two important questions: (1) What information is required to estimate benefit-cost ratios for future research expenditures? and (2) How can this information be analyzed in a manner that is not misleading and yet is simple enough so it does not exceed the time and resource constraints placed on the evaluation process?

CORN AND SOYBEAN RESEARCH

The North-Central region's research request was evaluated by the USDA Budget Committee because the increase in corn and soybean research funds is concentrated in that region.[3] The analysis was further narrowed to include only the new research in the two research program areas (RPA's) with the largest requests:

(1) RPA's 207-209: Crop protection from insects, diseases, and weeds for corn and soybeans

(2) RPA 307: Improvement of biological efficiency of crop production for corn and soybeans

Scientists from the land grant universities provided estimates of yield and cost effects and adoption rates for technology developed with the new research funds. The low end of their range of estimates was used in the analysis (table 1). To calculate the benefit-cost ratios for each RPA, the following assumptions were made: (1) a discount rate of 10 percent, (2) harvested acreage held constant at the 1975 level, (3) corn and soybean quality remaining constant or the increase in quality not lowering livestock feeding costs, (4) a corn price of $2 per bushel and a soybean price of $4.75 per bushel, (5) a probability of success of 0.8 for corn and 0.5 for soybeans, (6) the lag in adoption of new methods as shown in table 1, (7) benefits beginning in the year specified in table 1 and ending in the year 2000, and (8) research impacts occurring only in the North-Central region.

Several of the above assumptions are probably conservative. The reporting scientists estimated that production costs would decline as a result of the increased research. They also thought that the protein quantity and quality in corn should improve because of added research in RPA 307 which would lower feed costs. However, for simplicity in the analysis, only yield increases were counted as benefits even though the cost reductions would afford the same benefits as greater yields. Finally, the prices assumed for corn and soybeans were based on projections which assume no increase in exports over the period.

Benefit-Cost Estimates

The data can be incorporated in a simple framework to arrive at the benefit-cost ratios. The ratios calculated for corn and soybeans are all extremely high (table 2). The low is $9 in benefits per dollar cost for improvement of biological efficiency of soybeans under assumptions of long lags, limited probabilities of success, and moderate yield increases. The high is $172 in benefits per dollar of cost for protection of corn from insects, diseases, and weeds under an assumption of relatively higher prices for corn. The benefits from corn research in the North-Central region are especially high because the yield increases occur over such a large acreage.

The importance of the acreage affected can be illustrated by considering the Southern region. There, corn acreage in 1975 was 8.8 million acres, compared with 54.7 million in the North-Central region. If the same yield increases are assumed for the Southern region, the benefit-cost ratios range from 5 to 26 for corn in RPA 307. This range is for the same research expenditure as in the North-Central region, and it assumes that the research only affects the Southern region. Benefit-cost ratios would not be reduced as much for soybeans since the Southern region's acreage is about a third that of the North-Central region.

[3] A similar analysis was done for the Southern region but is not reported here because of the difficulties involved in separating the new research from the research bases.

Table 1.—Information required for estimating returns for public research to increase corn and soybean production, North-Central region

Crop	RPA	SY[1]	Dollars per SY (000)	1975 Yield	1975 area	Change in yield by year 2000	Year available	Adoption pattern[2]			
								1st year	2nd year	3rd year	4th and later years
		Number	*1,000 dollars*	*Bushels/ acre*	*1,000 acres*	*Percent*		*Percent of total area*			
Corn	207-9	2.5	77.1	88.9	54,722	2	1982	30	50	75	75
Corn	307	3.0	72.3	88.9	54,722	2.25	1985	30	60	80	80
Soybeans	207-9	1.5	69.6	31.1	33,557	1	1982	30	50	70	85
Soybeans	307	3.0	74.4	31.1	33,557	2	1985	40	70	90	95

[1] SY stands for scientist year. Dollars per SY includes the cost of the scientists' salary as well as supporting facilities.
[2] Adoption patterns allow for a lag in the influence of the programs. For example, the research results from RPA 207-9 will be adopted on 30 percent of the corn acreage in the year the new research is available. In the second year it will be adopted on 50 percent of the corn acreage, and in subsequent years, it will be adopted on 75 percent of the acreage.

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Table 2.—Sensitivity analysis of the benefits and costs of new production research on soybeans and corn

Benefit-costs	Corn		Soybeans	
	RPA 207-9	RPA 307	RPA 207-9	RPA 307
1. Under initial assumptions	137	118	45	40
2. With longer lags	117	102	38	30
3. With lower probabilities of success	86	74	27	24
4. With both longer lags and lower probabilities	73	64	24	19
5. With $2.50 corn and $5 soybeans	172	148	47	42
6. With 50 percent smaller yield increase	69	59	22	20
7. With both lower yield increase and lower probabilities	43	37	13	12
8. With lags, probabilities, and yield changed	37	32	12	9

Using corn for RPA 307 as an example, benefits can be calculated for the North-Central region from table 1 as follows. Yields are expected to begin to increase under the program in 1985, rising to a level 2.25 percent above that of 1975 by the year 2000. That is a rise of two bushels per acre (88.9 times 2.25 percent) or 0.125 bushels per year for 16 years. If the probability of success is 0.8, then a gain of only 1.6 bushels is expected by the year 2000. Allowances for the adoption pattern on the 54,722,000 acres provide an estimate of the added corn production for each year.

To illustrate, in 1985, only 30 percent of the 54,722,000 acres will realize the expected increase of .125 bushels per acre. In 1986, 60 percent will have adopted the 1985 methods and 30 percent, the 1986 methods. The annual increase in production is multiplied by $2 per bushel to estimate the total receipts or undiscounted benefits for each year. These benefits range from about $3 million per year in 1985 to over $133 million in the year 2000. Using a discount rate of 10 percent, this future stream of income would have been worth $200,476,000 in 1975.

Costs are $216,900 per year for 3 SY's at $72,300 per SY. The value of the stream of expenditures was $1,696,961 in 1975. The benefit-cost ratio for corn from RPA 307 is: $200,476,000 divided by $216,900 equals 118.14. That is, one dollar of costs is expected to return $118, as viewed from the starting year of 1975 (table 2, row 1).

The benefit-cost ratios are sensitive to changes in assumptions concerning the length of lags, probability of success, prices, and yields. For example, scientists may tend to be overly optimistic in their estimates of future yield increases. Also in light of past research productivity estimates made by Bredahl and Peterson (*1*), the yield increases seem high. To adjust for a possible optimistic tendency, three of the sets of benefit-cost ratios were calculated assuming that the yield increases were only 50 percent of the yield estimates.

As a check to see if the reduced yield increases are reasonable, all scientists from the North-Central region working on corn in RPA's 207-209 and 307 were assumed to be just as productive as the new scientists. With yield increases reduced to 50 percent and the lower probability of success, corn yields in 2000 would be 16 bushels higher because of the research. In other words, corn research in the land grant universities in the North-Central region would increase corn yields in the region by 18 percent in 25 years. Assuming only the 50-percent reduction in yield increases for soybeans, scientists from the North-Central region in RPA's 207-209 and 307 would increase yields 3 bushels, or 10 percent, in 25 years. Both outcomes seem quite reasonable in light of the past productivity of agricultural research expenditures in cash grains (*1*). The outcomes also indicate that the reduced yield increases are more realistic, particularly for corn.

The sensitivity of the benefit-cost estimates to changes in assumptions, concerning length of lags, probability of success, prices, and yields, appears in rows 2 to 8 of table 2. First, we extend the lag between the research expenditures and the availability of the results for adoption. The lag is increased from 7 to 10 years for RPA 307 and from 4 to 6 years for RPA's 207-209, which lowers the ratios (row 2). Second, the probability of success assumption is reduced from 0.8 to 0.5 for corn and from 0.5 to 0.3 for soybeans. Again, the ratios are lowered (row 3). Third, we increase the length of

lag and reduce the probabilities of success, both of which lower the benefit-cost ratios. Fourth, the prices of corn and soybeans are increased to $2.50 and $5, respectively. These prices are closer to 1976 prices and raise the ratios substantially, as shown in row 5. Fifth, the yield increases are reduced by 50 percent, and the ratios are lowered (row 6).[4] Sixth, the yield increases and the probabilities of success are both reduced, which further lowers the benefit-cost ratios. Finally, the length of lag is increased, the probability of success reduced, and the yield increases lowered by 50 percent. These changes lower the ratios substantially but, as indicated above, the reduced yield assumptions are more consistent with past trends. Yet the ratios remain high, indicating research has a high payoff over a wide range of assumptions.

Other USDA budget committee members similarly analyzed new research for wheat, beef cattle and forages, dairy and swine, and results could also be generalized to other crops and livestock.[5] The analysis could be applied to the research base as well, although it would be more difficult to ignore the following questions. How much research is necessary just to maintain current levels of production and how important is the interaction among different types of research projects and among scientists? Can one evaluate corn breeding research separately from that for wheat breeding or new pesticides?[6] Adjustment problems will be more important if the total research base is evaluated. Will the increase in production due to research reduce farm incomes enough to drive large numbers of farmers out of business (7)?

[4] Note that a 50-percent reduction in the acreage affected by the new research would have the same impact as the yield reduction. However, the adjustment implied by such a large reduction in acreage would mean an increased rate of farmers moving out of agriculture and more declining rural communities.

[5] The benefits from beef cattle-forage research were measured in terms of reproductive efficiency, reduced cow maintenance costs, and lower costs per pound of gain. Swine research benefits were measured in a similar manner. For dairy cattle, increased milk production per cow and improved reproductive efficiency were used to measure benefits. Research to improve animal health will likely be important for all classes of livestock and will be reflected in several of the benefit measures. For example, improved animal health could improve reproduction efficiency and reduce the cost per pound of meat or milk.

[6] A more difficult task would be to evaluate the rural development research and extension. It is much more difficult to put a dollar value on rural development extension than on an additional bushel of corn. Thus, in evaluating rural development research and extension, cost-effectiveness analysis may be more appropriate than benefit-cost analysis because benefits need not be valued. Cost-effectiveness analysis would require three kinds of information: (1) a listing of specific objectives, (2) a cost breakdown by project and objective, and (3) a display of projected outcomes in physical terms, if possible. Finally, the proposal should be compared with the cost of alternative methods of obtaining similar results.

Distribution of Benefits

The benefit-cost ratios reveal nothing about the distribution of benefits between farmers and consumers., Benefits and costs of increased production are passed along to society in many ways. The additional corn and soybeans will move through markets and generate employment as well as other economic activity. Increased supplies will create downward pressure on prices which reduces the value of the increased production to farmers and raises the benefits to consumers.

Lower corn prices cause downward pressure on livestock prices as feed becomes cheaper. The impact of lower livestock prices spreads to the wholesale and retail sector and benefits consumers. Lower soybean prices have a similar effect on livestock prices and also affect the markets for margarine, shortening, and salad oil (*12*). The effects spread through a wide portion of the agricultural sector and, to a certain extent, the foreign trade sector as well.

To help measure the distribution of the research impact, we used estimates published in a recent report by the National Academy of Sciences (*12*). For that study, several econometric models were combined and the resulting impact multipliers used to obtain empirical estimates of the effects of pest control on soybeans and corn. Estimates were made, based on this report, of the effects on prices in the feed/livestock/meat economy of a 3-percent increase in corn and soybean production (table 3).

Table 3.—Estimated changes in prices due to a 3-percent increase in corn and soybean production in the United States

Item	Corn	Soybeans
	Percentage change	
Prices received by farmers for corn	—3.1	---
Prices received by farmers for soybeans	---	—2.9
Soybean meal prices at wholesale	---	—1.5
Soybean oil prices at wholesale	---	—4.5
Price of fed cattle	—1.1	---
Retail price of beef	—.93	—.06
Farm price of pork	—1.3	—.24
Retail price of pork	—.72	—.15
Wholesale price of broiler chickens	—1.6	—.54
Retail price of chickens	—1.2	—.39
Retail price of eggs	—1.1	—.21
Retail price of margarine	---	—3.7
Retail price of shortening	---	—6.3
Retail price of salad oils	---	—4.3

Source: Based on estimates in National Academy of Science Report (*12*).

--- = not applicable.

Because the increase in production generally causes a corresponding decline in price, consumers are the major beneficiaries. To illustrate, assume the initial price of corn is $2 per bushel and production is 5 billion bushels (figure). If production increases 3 percent, the price of corn drops approximately 3 percent (table 3). The research effort has increased production by shifting the supply curve from S to S′. Consumers gain A + B in consumer surplus from the increased production and lower price. The change in gross returns to producers is represented by the gain of C minus the loss of A. Note that we are comparing the change in consumer surplus with the change in gross returns to producers and not with "producers surplus." Quantitatively, the following effects have occurred: (1) the 3-percent increase in production means a gain of 0.15 billion bushels of corn, (2) the price drop of 3 percent means a decline from $2 to $1.94, (3) the gain in consumer surplus equals A + B $\approx$ 0.06 x 5 billion bushels + (0.5) (0.06) x 0.15 billion bushels = $304.5 million, (4) the change in gross returns to producers equals C–A which equals $1.94 x 0.15 billion bushels ($291 million) – $300 million = -$9 million. In summary, consumers gain $304.5 million while producers lose $9 million in gross returns.

As with corn, the farm price effect of the increased production of soybeans offsets the production effect, leaving gross farm income from soybeans virtually unchanged. The price effect is especially strong for soybean oil, and this spreads into the fats and oils sector. The longrun effect on livestock is a half of 1 percent or less.

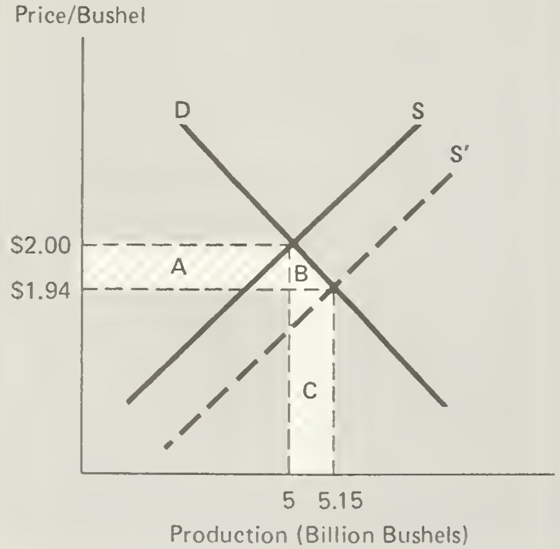
The analysis of corn and soybean research shows that there will likely be a high return with effects spreading throughout the feed/livestock/oils sectors. In the end, the consumers will be the major beneficiaries. However, to the extent that exports are more price responsive, the price effects will be smaller, and farmers will benefit more. There will also be an increase in foreign exchange earnings if export demand is elastic.

Conclusions

The application of benefit-cost analysis to future land grant universities' budget requests for agricultural research and extension will be a major task. However, the task seems feasible, particularly for crop and livestock research. A major advantage of this type of analysis is that it can be kept simple. The key in the analysis is the cooperation of the scientists; their estimates of potential outcomes are critical. Sensitivity analysis can be used to present policymakers with a range of returns under varying assumptions. If time permits, the results can be strengthened with estimates of the distribution of benefits between consumers and producers.

Based on the analysis of corn and soybean research, it appears that the land grant universities' research expenditures will bring a high return.

Impact of Research on U.S. Corn Production



In Earlier Issues

Studies in land tenure . . . emphasized the opportunity for a young man to attain farm ownership through a series of steps under which he served an apprenticeship while acquiring the necessary capital. This series of steps, called the agricultural ladder, progressed from farm laborer to tenant to mortgaged-owner to full ownership . . .

In more recent years considerable interest has developed in father-son farm agreements which approximate a partnership to help the agricultural ladder to function. This type of tenure arrangement has its origin in three increasing trends: A greater capital requirement in farming, a longer period of life expectancy, and better opportunities for employment off the farm . . .

Recent trends in decentralization of industrial activity and increased professional services have offered farm youth more opportunities for employment off the farms. Farm youth who are not interested in farming as an occupation have found it easy to get started in other vocations.

"Father-Son Farm Agreements in Virginia," by W. L. Gibson, Jr. and F. D. Hansing. AER, Vol. I, No. 3, July 1949, p. 78.

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REGIONAL RESOURCE USE AND COMMODITY SUPPLY RESPONSE

By Richard M. Adams and Robert B. McKusick*

INTRODUCTION

Methodology for regional economic projections used in comprehensive planning and evaluation of water and related land resource use has been changing during the last 10 to 15 years. The changes have been occurring for several reasons:

- As a response to the economic, land, and water use information needs of the Water Resources Council (*33*, *34*);[1]
- As a result of the National Water Commission study suggesting higher levies to resource users and beneficiaries (*15*, *16*);
- In answer to questions regarding the consistent measurement of the value of goods and services to consumers and producers raised at the National Water Conference (*35*);
- As a result of a general concern for improved comprehensive agricultural forecasts and projections and more economic flexibility in water and land use policy and planning.

Abstract: The feasibility of quadratic programming as a means of integrating agricultural price-quantity relationships and regional resource availability is demonstrated for a California test case. Estimates are developed for producer's and consumer's surplus, values of vegetables and field crop production, and resource use considering alternative levels of commodity demand, functional price-quantity relationships, normalized prices, and OBERS production projections. The results of the study have implications for resource policy analysis, shortrun agricultural price forecast, resource situation and outlook work, commodity and resource projections, and an expanded role for regional river basin studies. Keywords: Quadratic programming, producer and consumer surplus, forecasts, projections, and resource planning, evaluation and policy.

The need exists for procedures which can be implemented at the regional level to develop: (1) a nationally consistent set of land (soil groups), water, production, and crop acreage projections for agriculture which can be used in river basin or regional studies; (2) a consistent set of prices to value alternative levels of production "with" and "without" program and projects, to determine national economic development benefits and costs;[2] and (3) intermediate projections (and methodology) based on shortrun cycles and longrun trends.[3]

The Economic Research Service (ERS) has the major responsibility for developing agricultural price, production, and resource use projections within USDA. Currently, applied methodology is lacking that ties commodity prices and quantities directly to regional resource use. In general, the river basin regional models of the Natural Resource Economics Division in ERS have traditionally been linear programming models, with commodity prices held constant, while "demand" restraints are imposed independent of prices. Prices and quantities tend to be developed exogenously, independent of the regional resource base.[4] Such models have been used to generate longrun projections (10-45 years) of land use and resource allocation.

Generally, national shortrun agricultural price-forecasting models which emphasize the interaction of prices and quantities ignore any interaction with the regional resource base and they do not consider regional comparative production advantages for crops. There is a need to incorporate these shortrun price-forecasting equations into regional programming models to endogenously determine regional production levels. Such methodology could enhance intermediate projections (2-5 years) through the expanded use of river basin regional programming models and improve regional shortrun forecasts of commodity prices and quantities and of resource use.

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[1] Italicized numbers in parentheses refer to items in Bibliography at the end of this article.

[2] For a discussion of the current multiple-objective planning and evaluation procedures, which involve the two objectives and four accounts used by Federal agencies, see (*14*, *24*, *27*, *32-34*).

[3] This problem was recognized in a recent survey article in *Agricultural Economics Research* by Boutwell, and others, which pointed out that "longrun projections models generally fail to pick up shortrun variations just as shortrun forecasting models usually do not pick up longrun trends" (*7*, p. 41).

[4] In a strict sense, quantity is endogenously determined, but within predetermined bounds. While the optimum quantity produced in the linear programming model framework does not always equal the specified quantity restraint (because of other market and resource restraints), most market restraints are usually reached.

The output of this integrated effort (commodity price, quantity, and resource base) could be a valuable input into resource situation and outlook reports and the formulation and analysis of resource policy.

OBJECTIVES

This article demonstrates the feasibility of a quadratic programming model with the objective function specified to maximize producer's and consumer's surplus—as a means of integrating price-quantity relationships and intermediate-run regional resource availability at the State level. A set of results is compared for a quadratic programming model for California,[5] first incorporating price-forecasting equations for vegetables and field crops, and then inputing the normalized price series (*34*)[6] and OBERS (*29*)[7] production constraints for field crops, under alternative "demand" situations for 1980. The specific objectives are to:

- Compare the value of the objective function and the value of production for California field crops and vegetables under moderate and high levels of demand (price projections) and OBERS production levels.
- Compare resource use under the above conditions; and
- Provide insights into the feasibility of using the more general equilibrium framework provided by quadratic programming (which incorporates demand curves in the objective function) in resource evaluation and planning, compared with using OBERS quantity projections and normalized price series.

THE MODEL

The mathematical model is similar to those developed by Duloy and Norton (*8*), Hazell and Scandizzo (*9*), and Simmons and Pomerada (*18*). However, the study model uses a quadratic solution procedure similar to that suggested by Takayama and Judge (*19*).

The most notable feature of these models is that they include product demand relationships through the use of price-forecasting equations. The fact that prices are an endogenous variable and the nature of the maximand makes these models well suited to use in agricultural planning. The maximand of the quadratic programming problem may be equated to the area under the demand curves above supply costs at the relevant quantity levels (that is, the Marshallian concept of economic surplus). This feature is particularly meaningful from a policy standpoint in that aggregate distributional effects may be determined (see *8*).

The study model contains a quadratic objective function and a convex linear constraint set. Specifically, the objective function takes the form:

$$\text{Max} \;\; \pi = q' \, (q + .5\text{D}q) - c' \, (q)^{8} \qquad (1)$$

where π equals the sum of producer's and consumer's surplus; q equals a vector of aggregate activity levels in quantity units (for example, 100 cwt, or 1,000 tons); and a and D are elements of the linear demand structure ($\text{P} = a + \text{D}q$) where:

a = vector of intercept terms;
D = negative diagonal matrix of slope coefficients; and
c = vector of activity variable cost levels

As discussed by Duloy and Norton (*8*), maximizing the objective function is analogous to maximizing the sum of consumer's and producer's surplus; that is, a perfectly competitive solution in which price equals marginal cost. Disaggregation of the objective function into consumer's and producer's surpluses may be used to measure welfare distribution quantitatively under different policy parameters. Such a disaggregation, under varying assumptions about price-quantity relationships for the commodities studied is discussed in a later section.

The model objective function is bounded by a convex constraint set of the form:

$$\text{A}q \leqslant b \qquad (2)$$

where A is an M x N matrix of production coefficients; and b is an M x 1 vector of resource availability.

To simulate a linear programming (LP) outcome (horizontal demand curves or constant output prices) for certain commodities, the negative regional D matrix

[5] A detailed discussion of this model, as well as a set of analyses of alternative energy input prices and quantities, appears in (*1*) and (*2*).

[6] "Current normarlized prices" are the price standards used by Federal agencies in evaluating agricultural effects of alternative development and management plans for water and related land resources.

[7] Currently, agricultural production projections used by Federal agencies for water and related land resource planning are the OBERS series developed jointly by the Economic Research Service and the former Office of Business Economics (now Bureau of Economic Analysis), U.S. Department of Commerce.

[8] The scalar value (.5) in the objective function ensures a perfectly competitive solution (intersection of supply and demand, or P = MC) rather than the monopolistic solution (MR = MC). That is, the first-order conditions (for equation 1) result in the perfectly competitive equilibrium:

$$\text{P} = a + \text{D}q = c' \, (q)\,' = \text{MC}.$$

Without the .5 element, the first-order conditions result in the monopolistic situation: $a + 2\text{D}q = c'_{.} \, (q)\,' = \text{MC}$, where the left-hand term ($a + 2\text{D}q$) is marginal revenue (*8*).

elements (slope coefficients) corresponding to the field crop set were adjusted to approximate a horizontal ("perfectly elastic") slope. This approximation (rather than a slope of exactly zero) was necessary to facilitate the quadratic solution procedure; that is, the diagonal elements of the D matrix must be nonzero. This adjustment, together with adjustment of the field crop intercept terms to normalized price levels (while maintaining downward sloping demand relationships for vegetables), resulted in the set of objective function demand relationships used to approximate the LP outcome.

Algebraically, equation (1) takes the following heuristic form for field crops under the normalized price-OBERS projections.

$$\text{Max } \pi = a'q - c'q \tag{3}$$

Vegetable demand slopes and intercepts remain at original values (as estimated or derived from secondary sources), except for intercept modifications under alternative demand assumptions. OBERS production data were not available for vegetables.

Three alternative models are analyzed:

- model I - the basic quadratic form, with price-forecasting equations for both vegetables and field crops;
- model II - a quadratic form with field crops set at approximately zero slope and intercepts at normalized price levels; and
- model III - the same form as model II except that OBERS production levels are added as right-hand-side constraints.

The results presented later from these three forms show the usefulness of quadratic programming as compared to normalized prices and OBERS projections in a linear objective function.

Because the quadratic programming model and the two variants are exercises in normative economics, any claims as to their predictive accuracy would be misplaced. The model results are conditional upon the reasonableness of the price forecasting equations. More flexibility may be incorporated into projections of resource use through the use of commodity price-quantity relationships and into the forecast of regional prices through the use of regional resource programming models.

Commodity Demand

The quadratic programming methodology used in this study required the specification of linear demand functions of the form:

$$p = a + \mathrm{D}q \tag{4}$$

where p is an $n \times 1$ vector of prices, a is an $n \times 1$ vector of constants, D is a negative diagonal matrix of price-quantity slope coefficients, and q is an $n \times 1$ vector of quantities. These relationships are specified at the farm level. The diagonal D matrix means zero cross-effects for competing commodities at the farm level.

The general specification of the farm level price-forecasting equations includes variables for California production, production in other regions, and other variables, where:[9]

$$Pc_i = f\,(Qc_i,\ Qo_i, S_i, Y)$$

and

Pc_i = season average price received by farmers in California for commodity i
Qc_i = production in California
Qo_i = "other" U.S. production
S_i = existing U.S. stocks
Y = U.S. aggregate disposable personal income
and
f is a linear functional form.

Seasonal and annual price-forecasting estimates of 37 commodities (including seasonal subsets of the 18 model commodities) were required, 33 of which were obtained with the above price-forecasting equation.[10] Price-quantity relationships for the remaining four commodities where simultaneity was suspected were derived from more detailed econometric studies.[11] The employed price-forecasting equation slope and intercept values are published in (*1*) and (*2*).

OBERS Projections

Currently, the OBERS series represents the agricultural production projections used in water and related land resource planning at the Federal level. The projections of regional economic activity made for 190 water resource subareas include national production "requirements" to meet specific consumption, population, and import-export assumptions. Traditionally the regional production shares have been determined by historical trends.

These economic projections and supporting data base serve two purposes:

> First, they are an essential input for estimating the demands for water and related land. Second, they constitute a framework for estimating the economic effects of specified water constraints

[9] Econometrically, it appears reasonable to treat some annual crop production as predetermined within the crop year. Thus, quantity can be used as an independent variable in least squares price-forecasting equations to obtain unbiased statistical estimates.

[10] Independent variables other than "production in California" were evaluated at mean levels and added to the intercept terms in the objective function specification. The result was general price-forecasting equations of the form $Pc_i = a_i + d_iQc_i$. The addition of "other" explanatory variables to the intercept term is consistent with the model's emphasis on price prediction.

[11] The four commodities and the sources from which they were derived are: cotton (*6*), processing tomatoes (*12*), sugar beets (*4*), and safflower (*10*).

and of alternative programs for developing and managing the Nation's land and water resource (*30*, p. 5).

The conceptual basis underlying OBERS U.S. agricultural projections is supposed to be that of a general price equilibrium. According to the Water Resources Council, projected commodity per capita consumption is to be tied to a set of price-quantity relationships, in which national production projections reflect specified relationships between consumption and income, potentials for product substitution, and the price elasticity of product demand.

In the future, the OBERS production projection model will depend on these factors: baseline per capita consumption projections, price elasticities for all commodities, cross elasticities where appropriate, exports, enterprise budgets, and national interregional competition (*7*, p. 49). Such a model will generate regional production levels to be used as inputs in constrained regional optimizing models. But, even with these changes, the proposed model fails to recognize that regional demand influences price and regional supply is responsive to price changes. For resource planning and evaluation, consistency between regional production levels and national price levels will not be realized. That is to say, for resource planning and evaluation in the "principles" and "standards" framework of the Water Resources Council, the distinction between regional and national economic benefits and costs will still be unclear (*33*, *34*).

Normalized Prices

"Current normalized prices" are the price standards used in evaluating agricultural effects of alternative development and management plans for water and related land resources. The current procedure uses an Almon polynominal distributed-lag method based on a 5-year period (*3*, *17*). The resulting prices for planning purposes have been published by the Water Resources Council (*36*).

The current procedure, as with previous normalized price procedures (*25*) has not been integrated with OBERS production levels (or optimum production levels obtained from regional LP models) to determine the value of goods and services from a plan or project (for national economic development objective and account entries). It is questionable whether these quantities (production) and prices are in "equilibrium".

The study analyses for 1980 are based on the 1980 OBERS Series E production projections and normalized prices using the polynomical distributed-lag procedure for 1970-74 (table 1). New data have since been developed based on OBERS Series E -High Export, and normalized prices using 1971-75 data. These new data for California field crops show a slight decrease in prices (because of lower prices in 1975 and the weighting procedure of the distributed-lag approach). Projected production requirements for California field crops remained basically constant in 1980 except for increases in corn and grain sorghum.

DATA

Production Regions, Cropping Activities, and Resource Constraints

California is a major agricultural production region, producing a diverse, high-value, crop mix. Favorable climatic, soil, and water conditions have enabled the region to assume national dominance in the production of fruits and nuts, vegetables, and specific field crops. Changes in California production of these crops can significantly affect regional and national prices.

Table 1.—Normalized prices and 1980 OBERS production, California

Crop	Units	"Normalized" price (dollars per unit)[1]	1980 OBERS Series E production, California
			Thousands
Barley	Bushel	2.70	75,161
Beans, dry	Cwt	24.60	3,101
Corn, grain	Bushel	3.39	[2]23,987
Rice	Cwt	9.13	25,531
Sorghum, grain	Bushel	3.10	36,599
Sugar beets	Ton	32.62	7,839
Wheat	Bushel	3.16	[2]31,019

[1] Normalized price series is that obtained using the polynomial distributed lag procedure for 1970-74. [2] Corn and wheat data were not presented for California in the OBERS publication. Based on 1972-74 average production.

Source: ERS, Regional Projections Analytical System, preliminary prices and projections; and U.S. Water Resources Council, *1972 OBERS Projections Regional Economic Activity in the U.S., Series E Population Supplement* p. 59, table 2, May 1975.

Eighteen irrigated annual crops are included in the analysis: barley, beans (dry), broccoli, cantaloupes, carrots, cauliflower, celery, corn, cotton, grain sorghum, lettuce, onions, potatoes, rice, safflower, sugar beets, tomatoes (fresh and processed), and wheat. Perennials were not treated due to their complex time horizons. To account for seasonality of production (important for vegetables) and the diversity of California climatic zones, 14 production subregions and seasonal and annual cropping activities were specified.

Fixed resources (right-hand-side restraints) related to onfarm usage include land (of two quality types), irrigation water (ground and surface), fuel (gasoline and diesel), and nitrogen fertilizer. Institutional restraints, in the form of maximum processing capacities for processing tomatoes and sugar beets, were imposed. Market restraints in the form of OBERS production levels and normalized prices were imposed on models II and III.

EMPIRICAL RESULTS

The empirical results include the values of producer and consumer surplus, production levels and acreage for vegetables and field crops, and resource usage for California. Solutions for the three models[12] were obtained for both a moderate and high set of demand assumptions for 1980, resulting in a total of six model solutions.[13] The moderate and high demand assumptions apply only to the price-forecasting equations. The OBERS production levels and normalized prices were held constant.

Objective Function

The maximand of each model is analogous to maximizing the area under the crop demand curves less supply cost. Alternatively, this procedure may be compared with maximizing the sum of consumer's and producer's surplus. The slope and intercept of each price-forecasting equation affects the total value of the objective function as well as the respective components. The "flatter" or more elastic demand relationships may be expected to yield higher levels of producer's relative to consumer's surplus than more steeply sloped relationships. Therefore,the use of normalized prices (with "flat slopes") or perfectly elastic demand curves for field crops, with and without OBERS production restraints, will by definition tend to result in distributional and absolute changes in the objective function and resource use. The objective function values for each model, under respective demand assumptions, are presented in table 2.

The total value of the objective function under moderate demand, when compared with the quadratic solution (I), increased under both normalized-price, perfectly elastic demand (II), and normalized price-OBERS constraint models (III). Such an observation is consistent with the high level of field crop prices portrayed in the distributed-lag series, and the non-depressing effect on prices of horizontal slopes for these commodities. Thus, the use of normalized prices, even with OBERS constraints, tends to result in slightly higher objective function values than the base quadratic solution, under "moderate" demand adjustment. Model I shows the objective function to consist of about 65 percent producer's surplus and 35 percent consumer's surplus. Under the perfectly elastic (except vegetables) model II the percentages are about 90 and 10, compared with 78 and 22 for the constrained model III.

Under a high demand assumption (reflecting the high commodity price levels of 1973-74), the quadratic base solution (I) displays a higher value than the other models, partly because of a heavy mix of vegetable crops in the solution and field crop price intercepts (reflecting 1973-74 price levels) that exceeded the normalized price. The mix between producer's and consumer's surplus for each model output for which the measure is meaningful is roughly two-thirds and one-third. Consumer's surplus is greater than zero in models II and III only because of the downward-sloping demand relationship for vegetables.

Value of Production

The value of production (index numbers) of vegetables, field crops, and total production appears in table 3 (for moderate demand) and table 4 (for high demand).

Field crop production increased significantly under the conditions of model II, compared with the quadratic solution (model I), a result which is consistent with the nondepressing effect on prices of the horizontal slopes for field crops. This increase comes at the expense of vegetable production, which maintains the downward sloping demand relationships. When the OBERS production restraints are added to the horizontal demand curves for field crops (model III), field crop production decreases relative to that in model II, because of the constraining level of the OBERS projections.

With moderate demand adjustment for vegetables

[12] As noted, the comparative analysis across the three models discussed is not intended to provide evidence as to how well a normative model can predict. However, for comparative purposes, the quadratic model was selected as the logical base, given that models II and III represent progressively constrained versions of the quadratic. Additionally, the quadratic model has been fairly accurate in depicting selected field and vegetable crop production patterns for California in previous research (*1*).

[13] Variation in farm level price would be expected to affect production responses, for specific commodities and in the aggregate. To test sensitivity of the model solution to overall changes in commodity price levels, two demand assumptions (moderate and high) were incorporated. The moderate assumption involves an overall increase in prices (intercepts) of 50 percent above levels in 1972, while the high assumption reflects intercept adjustments for the price-forecasting equations corresponding to highest price levels observed in 1973-74 for each commodity.

Table 2.—Value of the objective function, producer's surplus, and consumer's surplus under alternative demand and model assumptions for 1980

Demand assumption and model	Objective function value	Producer's surplus[1]	Consumer's surplus[2]
	Thousand dollars		
Moderate Demand:[3]			
I. Base model, quadratic solution[5]	1,069.865	688.291 (64.3)	381.575 (35.7)
II. Perfectly elastic demand model, normalized field crop prices and no OBERS production restraints	1,304.108	1,163.196 (89.2)	140.912 (10.8)
III. Constrained, perfectly elastic demand model, normalized field crop price and OBERS production restraints	1,100.695	849.312 (77.2)	251.384 (22.8)
High demand:[4]			
I. Base model, quadratic solution[5]	1,789.705	1,183.981 (66.2)	605.724 (33.8)
II. Perfectly elastic demand model, normalized field crop prices and no OBERS production restraints	1,642.438	1,268.342 (77.2)	374.097 (22.8)
III. Constrained, perfectly elastic demand model, normalized field crop price and OBERS production restraints	1,536.866	1,013.677 (66.0)	523.189 (34.0)

Note: All models maintain the conventional downward-sloping price-forecasting equations for vegetables. Thus, there will be consumer's surplus values for models II and III, due primarily to vegetable production. Values in parenthesis are percentages.

[1] Producer's surplus, as used here, represents returns to land and management. [2] The model maximands are analogous to maximizing the sum of producer's and consumer's surplus; that is, area under the demand curve and above supply costs. Hence, the difference between the objective function and producer's surplus may be equated to consumer's surplus. [3] Moderate demand refers to a uniform increase in commodity prices (intercepts) of 50 percent from levels in 1972. [4] High demand reflects an adjustment in commodity prices corresponding to the highest observed prices for 1973-74, for each commodity. [5] Quadratic model incorporates price-forecasting equation for both vegetables and field crops, with no normalized price or OBERS considerations.

Table 3.—Index numbers of value of production for vegetables and field crops under models I, II, and III, moderate demand[1]

Production	Moderate demand adjustment for vegetables[2]					
	I. Base model—quadratic solution		II. Perfectly elastic demand model-normalized field crop prices and no OBERS production restraints		III. Constrained perfectly elastic demand model—normalized field crop price and OBERS production restraints	
	Index number	*Percentage change*	*Index number*	*Percentage change*	*Index number*	*Percentage change*
Vegetables	100	---	62	—38	84	—16
Field crops	100	---	209	+109	123	+23
Total	100	---	112	+12	97	—3

[1] Index numbers represent a Laspeyres price index developed using commodity prices from the models solutions as weights. [2] Moderate demand refers to a uniform increase in commodity prices (intercepts) of 50 percent from levels in 1972.

Table 4.—Index numbers of value of production for vegetables and field crops under models I, II, and III, high demand[1]

Production	High demand adjustment for vegetables[2]					
	I. Base model—quadratic solution		II. Perfectly elastic demand model-normalized field crop prices and no OBERS production restraints		III. Constrained perfectly elastic demand model—normalized field crop price and OBERS production restraints	
	Index number	*Percentage change*	*Index number*	*Percentage change*	*Index number*	*Percentage change*
Vegetables	100	--	81	−19	89	−11
Field crops	100	--	129	+29	82	−18
Total	100	--	95	−5	87	−13

[1] Index numbers represent a Laspeyres price index using commodity prices from the models solutions as weights. [2] High demand reflects an adjustment in commodity prices corresponding to the highest observed prices for 1973-75, for each commodity.

(intercept term adjusted), field crop production exceeded that in the quadratic solution (I) (which is also moderate demand for both field crops and vegetables) under the assumptions of models II and III, while vegetable production decreased. In total, the OBERS constrained model under moderate demand revealed production levels somewhat similar to those in the base quadratic model. This similarity indicates that when adjustments in demand are gradual or moderate, normalized prices and OBERS constraints in an LP framework yield results somewhat consistent to those in the quadratic solution. There are disparities between vegetables and field crops, which indicate that OBERS production levels and normalized prices for field crops exceeded the estimated "equilibrium" price level relative to the quadratic solution.

Under a high demand adjustment for vegetables (and for all crops in the quadratic solution), the disparity between the quadratic solution (I) and the model II solution is reduced due to the increased comparative advantage of vegetables (high versus moderate demand). The value of the OBERS constrained solution (model III) for both field crops and vegetables was less than the value of the quadratic solution. The decrease in field crop production is expected due to the enhanced comparative advantage of vegetables. One would intuitively expect a relative increase in vegetable production under model III. However, because of regional production increases for selected field crops, particularly sugar beet production within the coastal valleys, resources are not available to expand vegetable production.

The results of the high demand assumption indicate that the LP framework, relative to the quadratic solution, lacks the flexibility to adjust to demand "shocks" such as the large price increase observed in 1973-74. Because of this inflexibility of prices and the fixed OBERS production restraints, the LP framework (compared with the quadratic) apparently has limitations for short and intermediate-run commodity supply response and resource use policy analysis and forecast.

Resource Use

Resource use generated from models I, II, and III appear in table 5. As a group, field crops are more land extensive than vegetables, their per acre water and fuel requirements are less, and their per acre fertilizer requirement is lower. Thus, any model which tends to favor production of one crop group over the other will result in differential rates of resource use. As a result, resource use depends on both total production and the commodity mix of production.

The demands placed on the land resource by the normalized price and OBERS models are consistent with the results presented in the production tables. The higher level of field crop production vis-a-vis vegetables is reflected in greater use of the land resource, compared with the base model. This is consistent with the more land extensive nature of field crops. Water demands are reduced in the normalized price-OBERS models (from base values) again consistent with the expanded field crop production and the generally lower water requirements of such crops. Fuel use tends to reflect the larger land area involved in the nonbase models.

Fertilizer usage displays no particular pattern in the various models, except for high demand model II. This behavior results from the highly differential rates of use among specific crops and the aggregate nature in which production is reported. For example, model II features an expanded production of dry beans, with a low per acre requirement for nitrogen fertilizer. This fact might not be obvious in terms of acreage if production of another field crop were reduced proportionately, but it

Table 5.—Aggregate resource use and index number for moderate and high demand levels, models I, II, and III

Resource	Unit	Moderate demand[1]			High demand[2]		
		I	II	III	I	II	III
		Million					
Land	Acres	2.142	2.480	2.229	2.178	2.506	2.295
Water	Acre feet	7.185	5.971	5.876	6.847	6.001	5.950
Fuel	Gallons	57.616	63.541	57.365	62.558	58.745	51.905
Fertilizer	Pounds	295.252	291.093	316.734	317.318	[3] 250.009	343.363
Resource use[4]		100	106	100	100	103	101

[1] Moderate demand refers to a uniform increase in commodity prices (intercepts) of 50 percent from levels in 1972. [2] High demand reflects an adjustment in commodity prices corresponding to the highest observed prices for 1973-75, for each commodity. [3] Decline in nitrogen fertilizer use is the result, in part, of substantial acreage increase in dry beans, a crop which uses relatively low amounts of such fertilizer. [4] Laspeyre's price index using approximate 1976 input costs as weighting mechanism.

would show up in a decline in overall nitrogen fertilizer use.

The OBERS constrained solutions, when compared with the quadratic solution, increased land use by only 100,000 acres but decreased water use by over 1 million acre feet. This results from the major shift to field crops.

RESEARCH AND POLICY IMPLICATIONS

The paper has discussed possible improvements in intermediate-term agricultural forecasting of price, production, and resource use by merging shortrun price-forecasting, intermediate-run income projections, and longer run regional programming models in an integrated system. A basic problem with current ERS forecasting and projections models is that commodity demand does not interact with the resource base and production relationships to determine regional equilibrium commodity prices and quantities. Once regional shares are determined, there is no corrective mechanism which allows for production adjustments based on changes in profitability or comparative advantage due to changes in the commodity price structure. This inflexibility to simultaneously vary price and quantity becomes even more important when major shifts occur in demand or regional production, as shown by the wide disparity between the results of model I and the normalized price results under high demand. Projections based on trend analysis would not anticipate these shifts.

ERS regional river basin models (in general, linear programming models) develop information which is basically resource related and emphasize production relationships and commodity supply. Current and projected regional information is developed for several factors: resource suitability and availability; crop suitability by land type or homogenous production area; crop yields and water coefficients by soils or production areas; and commodity production costs based on input levels, soils, methods of irrigation, resource problems (flooding, drainage, erosion, irrigation efficiency) and other resource use such as fertilizer, pesticides, gas, diesel, and labor. A weakness of such models is the lack of good demand restraints which consider both quantity and price in the derivation of regional commodity market shares. The idea of using aggregated demand projections as constraints for land and water projections is supported by the ERS Projections Task Force (*21*). But a critical aspect of these demand restraints is whether they will be developed exogenously or endogenously in regional models.

There is a need to merge the intermediate-run regional resource availability and productivity relationships of the river basin models with aggregate demand relationships. As pointed out by the ERS Projections Task Force (*21*, p. 13):

> Extended forecasts or outlook for events two, three, and four years hence are especially important for private investment decisions and public policy and program decisions. This is the period we should be focusing most heavily on because this is the period most meaningful to the crystal ball and tenure of policy makers and the period for which we have the most policy tools to use in altering undesirable outcomes. Immediate attention should be given to development of plans and responsibilities for a program of extended outlook (forecasts) to cover the period (one to four years) not now adequately covered by our short-term outlook program or the longer term projections program.

Commodity situation and outlook work should put more emphasis on resource availability and suitability as they affect commodity supply response. For example, the influence of weather (such as drought) on water availability in the West this year, and future landownership

patterns in the West have raised questions as to the supply response of selected agricultural commodities. ERS should explore the possibility of resource situation and outlook work, in particular, the suitability and availability of land and water in the intermediate run for agricultural production. ERS might also consider a resource policy analysis program area which combines resource situation and outlook work and longrun research findings.

The results obtained from the various quadratic formulations have implications for resource evaluation. By introducing demand curves directly into the regional analysis, regional output or benefits are not developed as "needs" or "requirements." As a result, the derived demand for resources becomes a function of commodity demand and not fixed production levels. Resource demand is sensitive not only to product price but also to relative resource cost relationships among gas, diesel, fertilizer, pesticides, and other inputs. If commodity price is allowed to respond to potential supply conditions in projection models, resource repayment capacities for future conservation, development, management and use may be effected. Such effects may be particularly important for water resource planning and evaluation. For example, actual water demands are substantially higher under the quadratic "base" results than for normalized price and OBERS models. Thus, the normalized price and OBERS results might understate the true demand for irrigation water in California.

As previously discussed by McKusick, Adams, and Snyder (*13*), a more flexible approach to resource planning and evaluation should recognize the interaction of production and consumption through the use of commodity demand curves. If the use of consumer's surplus as a measure of welfare is accepted, then differential impacts on producer's and consumer's welfare can be quantified by quadratic programming. Water policy makers need to consider these differential impacts. Consistency among resource agencies in setting economic criteria for water and related land resource planning and evaluation would be enhanced if national (and, in certain cases, regional) demand curves are integrated with regional commodity production, costs, resource availability and suitability, resource production relationships, and regional derived demand curves for resources.

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In Earlier Issues

Exploration of the possibilities of increasing industrial utilization of both the basic and the waste products of agriculture is extensive. The possibilities in increased utilization of farm products on the farm are less spectacular but they are just as significant and considerable effort is being directed toward developing them. Wherever it is feasible to substitue forage crops on acres now producing corn, cotton, or wheat, and to utilize these crops profitably through livestock, there are opportunities to combat effectively the threat of so-called surplus production. Adjustments of this kind also work in the direction of improving the national diet, conserving soil resources, and lending greater stability to farm incomes.

Neil W. Johnson
Volume I, Number 2, p. 57
April 1949

A SURVEY OF AGRICULTURAL ECONOMICS LITERATURE: VOLUME I, TRADITIONAL FIELDS OF AGRICULTURAL ECONOMICS, 1940's TO 1970's.

Edited by Lee R. Martin, Professor of Agricultural and Applied Economics, University of Minnesota. University of Minnesota Press, 2037 University Avenue, Minneapolis, MN; in Canada, by Burns and Mac Eachern, Ltd., Donn Mills, Ontario. 540 pages. 1977. $25.

In descending order of interest, there are books about people, books about events, books about ideas, and books about books. This is a book about books—a review of more than 2,300 books, bulletins, and papers in the traditional fields of agricultural economics. It covers virtually all prominent professional writing in agricultural economics from World War II to the early seventies. It is a prodigious piece of work.

The idea that gave birth to this undertaking came from C. E. Bishop, who, in 1968, as president of the Agricultural Economics Association, appointed a committee to investigate the need for a major survey of agricultural economics literature. On that committee were these prominent persons: Glenn L. Johnson, M. M. Kelso, James E. Martin, M. L. Upchurch, Lee R. Martin, John P. Doll, Peter Helmberger, J. Patrick Madden, and Edward W. Tyrchniewicz.

This committee delineated the field into three general areas, each to appear in a volume: Volume I, *Traditional Fields of Agricultural Economics*; Volume II, *Quantitative Methods in Agricultural Economics*; Volume III, *Economics of Welfare, Development, and Natural Resources.*

The current volume, first of the series, has seven parts, organized as follows:

Part I. Farm Management and Production Economics, 1946-70, written by Harald R. Jensen. Preparation of outlines: John P. Doll, Albert R. Hagan, Charles F. Harshbarger, and Joseph C. Headley, Review of papers: John P. Doll, Earl O. Heady, Glenn L. Johnson, and Max R. Langham.

Part II. The Analysis of Productive Efficiency in Agricultural Marketing: Models, Methods, and Progress, written by Ben C. French. Preparation of outlines: Peter G. Helmberger and Frank J. Smith. Review of papers: Emerson M. Babb, Peter G. Helmberger, Harold M. Riley, and James D. Shaffer.

Part III. Policy for Commercial Agriculture, 1945-71, written by G. E. Brandow. Preparation of outlines: James T. Bonnen, John A. Schnittker, Vernon L. Sorenson, and Arley D. Waldo. Review of papers: Willard W. Cochrane, David MacFarlane, Lauren K. Soth, and Luther G. Tweeten.

Part IV. Postwar Policies Relating to Trade in Agricultural Products, written by D. Gale Johnson. Preparation of outlines: Martin E. Abel and James P. Houck. Review of papers: T. K. Warley, Larry J. Wipf, and Lawrence W. Witt.

Part V. Agricultural Price Analysis and Outlook, written by William G. Tomek and Kenneth L. Robinson. Preparation of outlines: James P. Houck, Lester V. Manderscheid, and Edward W. Tyrchniewicz. Review of papers: James P. Houck, Richard A. Kling, and Edward W. Tyrchniewicz.

Part VI. Agricultural Finance and Capital Markets, written by John R. Brake and Emanuel Melichar. Preparation of outlines: Chester B. Baker, William H. Heneberry, John A. Hopkin, and George D. Irwin, Review of papers: Peter J. Barry, Fred Garlock, George D. Irwin, Lawrence A. Jones, Warren F. Lee, and John B. Penson.

Part VII. Technical Change in Agriculture, written by Willis Peterson and Yujiro Hayami. Preparation of outlines: Vernon W. Ruttan. Review of papers: Zvi Griliches and Vernon W. Ruttan.

The audience to which this volume is addressed is specified in the foreword:

> Research workers, teachers, extension workers and graduate students in agricultural economics; teachers, research workers and graduate students in economics and economic statistics, sociology, geography, political science, and anthropology; and teachers, research workers and graduate students in technical agriculture.

Professional rather than popular literature is reviewed.

Style and format are remarkably consistent throughout, evidence of what must have been the exercise of strong organizational efforts by editor Lee Martin. Typically, a chapter begins with a brief resumé of work preceding the post World War II period. The work then follows a topical pattern, topics one after the other more or less in chronological order. The works addressed to a particular topic are reviewed briefly as to their major thrust, with reference to the bibliography that follows each section. The chapter typically closes with a section on further research needs. These reviews can, perhaps, be described as being more interpretive than evaluative. Bibliographies, which are superb, are sometimes topically grouped and sometimes simply arranged alphabetically.

Seminal works are identified. Among the seminal authors mentioned, this reviewer notes the following:

- Earl Heady, for his many publications on production economics
- Mighell and Jones, for their work on vertical coordination
- T. W. Schultz, for his book *Agriculture in an Unstable Economy*
- Waugh, Nerlove, and Brandow, for their work on price analysis and
- Vernon Ruttan, for his writings on technical change.

The book is well written, but rather tedious when read in its entirety, as would be any annotated bibliography. But few people, other than the editor and the reviewer, are likely to read it cover to cover. The average reader will probably come to it in pursuit of some special interest. He will be helped by an excellent table of contents, with good headings and subheadings.

What impressions emerge for this reviewer after working through 540 pages bearing 2,308 references; These are not comments on the book, which is excellent, but on the research which is reported. After reading summaries of more than 2,000 pieces of work,

one would be dull indeed if he did not form some notions about it all.

First of all, the question arises, What difference does all this make? How has the development of agriculture been changed by all this research? The question was not addressed in this work, and it would indeed have been very difficult to address it. But it is a question being raised by State legislatures and members of the Congress who are asked to appropriate money for publicly supported research in agricultural economics.

The impression is clear that these researchers were writing chiefly for their peers. How their findings get injected into the decisionmaking forum is not really faced. Obviously, the feedback engendered by a given piece of work comes mostly from fellow researchers rather than from farmers, marketers, elected public officials, administrators, and financiers. The systems approach to research, so common in applied research in private industry, is not evident in the work reported in this book. Problem identification, the research undertaking, injection of the results into the decisionmaking forum, feedback from users, re-identification of the problem and a new loop of the cycle—this fruitful five-stage sequence appears, typically, to be pursued in only the first two stages and then repeated.

Another impression is that the researchers in the traditional fields of agricultural economics have generally operated within the existing power structure, whether this was political, economic, or professional. Acceptance of, and indeed defense of, the status quo has been a prominent feature of the work. Agricultural policies have been accepted pretty much as given, and much of the work is within that context. Agricultural economists, even though on the public payroll, appear to be agricultural advocates, much as labor economists are advocates of labor and industrial economists are advocates of business.

Should we expect it to be different? Challenges to the conventional wisdom have been fairly few, and when issued have been dramatically successful (as with Heady) or professionally damaging (as with those who didn't make it into the bibliography. Bibliographies, as with histories, are written by the winners.) True, this volume is the one on traditional areas of agricultural economics; perhaps the third volume, on the new research agenda, may reveal a more venturesome attitude on the part of researchers.

About half the money spent on agricultural research is spent by private firms. Few publications come from this work, and so the volume can contain little on such efforts. But considerable research on agricultural economics has been published by such privately supported sources as the Stanford Food Research Institute, Brookings Foundation, the American Enterprise Institute, the Committee on Economic Development, and others. These receive what seems to me less than their deserved attention.

This book is so comprehensive, so convenient, and so reputable that almost anyone who does research in agricultural economics should own a copy or have access to one. The time involved in researching the literature will be reduced to a fraction of what it would otherwise be. The weight of authority carried by this book in interpretations of past work will be persuasive.

This reviewer awaits with keen interest the volume on quantitative methods, scheduled to be published in late 1977, and the final volume on welfare, development, and natural resources, the publication date for which has not yet been set. This series, when added to earlier and quite different works by Benedict, Stine, and Taylor, will provide a good outline of the work of our profession.

Don Paarlberg
Professor Emeritus
Purdue University

RESOURCE ALLOCATION AND PRODUCTIVITY IN NATIONAL AND INTERNATIONAL AGRICULTURAL RESEARCH

Edited by Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan. University of Minnesota Press, Minneapolis, MN, 55455, 617 pages. 1977. $25.

Possibly one of the more puzzling aspects of the great growth in agricultural production, to which we have given the name "green revolution," is *how did it happen?* Belief is widespread that research and related activities had a significant role. Certainly, there have been extensive efforts to prove that research is the basis of growth, and developed and developing countries alike have invested great sums to increase agricultural productivity based on this belief.

Now, as the international agricultural research community reaches an advanced stage of adolescence, the desire and, indeed, need to know just exactly how it happened becomes more than an academic question. What might be termed "the easy stuff" has now been done for the most part. What follows will come harder and will cost more.

A conference held at Airlie House, Virginia, in 1975, from which the papers in *Resource Allocation* are derived, addressed this issue of how it happened. Participants discussed recent evidence of the impact of research on agricultural productivity, as well as the factors dictating the demand for and supply of new technology, and the complex infrastructure necessary for the infusion.

Resource Allocation contains six sections plus an introductory chapter. The first section presents papers on the productivity of national research systems, providing evidence from several countries. The second section contains papers on the productivity in the international research system, giving evidence of its success. In the third section, authors address the history and problems in the organization and development of the international agricultural research institute system. The fourth section evaluates both the macro and micro considerations in the organization and management of agricultural systems. In the fifth section, authors address the role of economic and social factors in research resource allocation, especially as they affect determination of priorities and optimal systems. In the final section, authors consider research strategies and administrative issues that will influence the future of the international research system.

The conference was especially eventful in two respects. First, it occurred at a time when the international agricultural research community was at a significant juncture. The

basic nature of research undertaken is changing, and national research capabilities are beginning to assert a greater role in both the conduct of research and its determination. The latter is particularly significant. Those concerned with the international agricultural research system, while pleased with its past accomplishments, are now questioning the direction and rate of future thrusts.

Second, the cast of participants at the conference were the "Who's Who" of the international agricultural research community. They included: the leading students of and most prolific writers on technological change; the leading organizers and administrators in the agricultural research system; and, a number of the current practitioners. To my knowledge, this is the first and only time such an assemblage of talent has been brought together on this topic, certainly exceeding the more narrow and less complex examination at the predecessor conference in Minnesota in 1969.* The individual papers reflect well the level of competence and depth of experience of their authors. Unfortunately, space did not permit the editors to also include fully the range of issues, variety of perspectives, depth of implications, and vehemence of persuasion contained in the interchanges among conference participants.

There is much in this book for serious consideration and discussion, and much for disagreement. One may raise questions about the efficiency criterion in resource substitution as the singular guide to technological change, or the role of economic growth as the singular goal of such change. Both are considered the heart of research allocation in these papers, as in technology literature generally. Problems in measures of returns to, and/or impacts of, research are generally attributed to problems of methodology resulting from uncertainty and bad data, rather than shortcomings in our theory. Are there alternatives to this relatively simplistic criterion and goal? Within the context of current, market-oriented firm theory, probably not.

Even at the firm and project level, the criterion and goal never have been acceptable in practice as singular guides to allocating resources. Now ample evidence is arising from the "small is beautiful" and "appropriate technology" trends and even from the conference papers to indicate a growing need to integrate these trends with other social criteria in determination of optimality. While in a number of the papers' authors stress these and other difficulties with the infrastructure of technological change, most seem to recommend only a need for change in the infrastructure, rather than a reexamination of our fundamental theories, decision criteria, and models.

An interesting conflict tends to lie just below the surface of many of the papers on organization and management of research, or on models of these, a conflict which may have far-reaching consequences. Western thought holds that research, to be most effective, must be organized, managed, and planned essentially within the context of entrepreneurship. Signals from the marketplace are believed to provide entirely adequate control over the allocation of resources among lines of research, and central direction in research is legitimate only where social opportunity costs of research investment would otherwise be too high. Participants from the developing countries believe a great deal of centralization in research planning is necessary. They would say that Western thought assumes the existence of too many factors (quality of marketplace signals, level of education, existence of technology delivery systems, and many other infrastructure characteristics) which simply do not pertain to developing countries.

Considering that Western thought has substantially dominated the international agricultural research system as to how it is organized, managed, and planned, one might speculate whether this dominance, in view of such philosophical differences, can continue. What role will Western research advisors be permitted in the further development of national research systems? Western advisors tend to be not well adapted to central planning.

Even in this country, the marketplace is visibly becoming a less efficient communicator of relevant choice values. As Schultz points out, these infrastructure problems require us to look beyond the realm of social scientists and research administrators for a resolution. Problems of infrastructure have not received the full attention that they rightly and necessarily deserve.

The overall conclusions of the volume are provided by Ardnt and Ruttan who state:

> There is solid evidence that investment in national and international research has been highly productive. The social returns to agriculture research have been high relative to the alternative investments available to most poor countries.
>
> There have been great strides forward in our understanding of how technical change is induced, in the modeling of the discovery process, and in mapping worldwide diffusion of technology and scientific knowledge (p. 25).

Yet, they conclude we need to know more—about the origin and nature of demand for new technologies, research cost functions and production processes, the technology diffusion process, and the infrastructure for technological change, especially that relating technology and economic policies. To this should be added the problem of reflecting nonmarket goal criteria.

If this book has a failing, it is probably in the size of the effort, in trying to cover too much material. There are at least three major topics included, each of which could fill a book itself: (1) the measurement of returns to investment in research, (2) the organization and administration of a research system, and (3) the purely micro-concerns of project selection and program management. While the principal aim of the conference was to provide an interchange among participants with expertise in each of these three areas, one might question the necessary sacrifice of alternative perspectives presented during discussions. It might have been better to sacrifice one of the three topics, concentrating on a fuller development of the remaining two.

This volume will be useful to a wide range of readers, because it does contain a vast amount of information. It provides an excellent primer for anyone entering the field of the international agricultural research system or to students of the technological process, whether from the standpoint of program organization and

*Walter L. Fishel, ed. *Resource Allocation in Agricultural Research.* Univ. Minn. Press, Minneapolis, 1971.

management or the measurement of returns to investment in research. There is much of worth to those who formulate research or development policy. It is an excellent general reference, and provides fine lists of materials for extensive reading in specific topics.

Walter L. Fishel
Agricultural Research Service

CONSERVATION AND ECONOMIC EFFICIENCY: AN APPROACH TO MATERIALS POLICY

By Talbot Page. Resources for the Future. Baltimore: The Johns Hopkins Univ. Press, 1977. 265 + xvii pp. $15 (hardcover), $4.95 (paper).

For many years there have been two approaches to the formulation of materials policy, one associated with the traditional thinking of resource economists and the other with that of conservationists. A national "policy" often emerges as the result of numerous individual decisions, subject to different pressures, and made over a long time, rather than from plans and goals formulated by a governing body. Policy formed after the fact takes on some of the contradictions accumulated over separate and disparate decisions. Our current materials policy falls into this second category.

This book offers a way to look at material flows that can be used in the formulation of materials policy. We can think of this formulation on three levels. At the most elementary level, there is a "large" quantity of waste, a "low" amount of recycling, and direct concern for resource availability in the future. The remedies are in the piecemeal tradition of our existing "policy"—subsidies on recycling, product specification, and so forth. At this level the focus is too narrow, like setting a particular sail of a ship without taking into account the balances among the sails. There is no relationship of one sail to another, no way of telling whether copper should be recycled at one rate and iron at another. Direct intervention may be self-defeating.

At the second level, correction of a single market failure leads to the improvement of several specific conditions concurrently. A market standard, such as the efficiency criterion, can determine in principle the best balance in material flows. For any particular course upon which the ship sails, we can define the proper or efficient balance among the sails. According to this criterion, the standard perceptions seen at the elementary level are all correct: the quantity of waste is too large, the rate of recycling is too low, there is too much depletion. At this level, particular policy directives can be readily formulated.

Consider the pricing structure for freight, electricity, and other forms of energy. The current structure favors users most sensitive to price, the largest users. The justification has been that volume discounts to the larger users built up capacity to take advantage of possible economies of scale.For freight transportation, bulk materials such as scrap and virgin materials were the intended beneficiaries of the pricing structure, but virgin materials benefited more. For energy pricing, the result has been to move extra materials around in the economy. However, the efficiency criterion tells us that there is an associated cost. A wedge is driven between the price of a material and its marginal cost, a wedge that distorts the price signal to downstream users. This distortion has been neglected. The issue is a complicated one involving tradeoffs of competing goals. Nevertheless, the policy direction inherent in the efficiency criterion is clear: move away from demand pricing and toward marginal cost pricing. This move would tend to conserve materials.

At this second level, the efficiency criterion guides us on the taxation of materials industries. Having noted low recycling rates, high rates of waste generation, and the relatively light tax burden on virgin material industries, one may find it easy to recommend equal tax treatment of secondary material industries. And in fact there have been many legislative proposals to extend the tax preferences on virgin materials to scrap materials as well. The efficiency criterion tells us that such a move would compound the materials problem. The result would be more material flowing through the economy, with increased costs of energy and capital to move the material around. There would likely be some saving in virgin material extraction and waste discharged to the environment, but this saving would come at unnecessarily high cost. The appropriate move, according to the efficiency criterion, would be to eliminate the tax preferences for virgin material. This has been done, in part, for major oil companies, but not for other materials industries.

While the efficiency criterion has long been a staple of the economic literature on depletable resources, it is probably safe to say that this criterion has not been an important concept in the legislative process.

For the third level, we step back to see where the economy as a whole is heading, and focus on the rudder. One view is that no attention need be paid to the rudder at all. The ship is on automatic pilot. The economy sails safely into the future much as Joshua Slocum sailed a thousand miles across the Pacific without adjusting his steering mechanism. Market forces provide a satisfactory balance between new technology and depletion, and the generation of long-lived wastes is not cause for concern. To adjust the rudder of the entire economy in its use of materials, it is necessary to look ahead 50 or 75 years. Different principles apply to the adjustment of the rudder than to the setting of the sails. The resource base is shared intergenerationally, and the questions are: Will it be shared fairly? In its use of materials how can the economy be kept from drifting into unlivable futures? To set and balance the sails requires considerations of economic efficiency; to adjust the rudder requires considerations of fairness. Some headway can be made in defining a fair resolution by imagining an agreement among representatives of different generations deciding on the management of the commonly owned resource base. Consideration of a fair use of the resource base is a legitimate and important concern in the formulation of materials policy.

A materials policy based in part on the conservation criterion is simple but probably counterintuitive. It suggests that when virgin materials threaten to become increasingly costly, they should be made more expensive nominally, perhaps by severance taxes, now. Often, people think just the opposite: when virgin materials

threaten to become more costly, they should be subsidized to keep prices constant to the consumer. The latter approach encourages the expenditure of more resources than may be returned from the effort in the short term; in the long term, it leads to a mismatching between the rate of depletion and technological renewal.

Of the three levels of consideration for the formulation of materials policy, the first, direct level is perhaps the most relied upon at present. It is the least suitable, because its focus is too close. There should be a mixture of the second and third levels. We need to know how to set the sails and how to adjust the rudder. In the past both skills have been neglected.

[Condensed from the book by Clark Edwards with permission from Johns Hopkins University Press.]

PROCEEDINGS, THE WORLD FOOD CONFERENCE OF 1976

Ames: The Iowa State University Press, 1977. 685 + xiv pp. $8.50.

When God created the world, He allocated His blessings in many ways incomprehensible to us so that it is impossible to detect what decision-making model He applied in determining who gets what, where, how much and why. To some He assigned the desert; to others He gave mountains, lowlands, and swamps; some received snow and others the monsoons; some too much water and others, no water at all. He also made us of different shades from white to brown to black with no indication as to why some would have fair skin, tall nose, and blond hair while there are those of us who are tanned, pugged-nosed, and short. However, we can have a pretty good guess as to why some were made women and others, men. In the allocation process, one occasionally suspects that He might have played favorites for a few more generously anointed with oil while some managed to inherit all the natural calamities—drought, flood, earthquake, cyclone, etc. . . .

It is just as well that we do not comprehend God's motives, otherwise there would be no end to the negotiations and to the bargaining for more concessions. Given this Master Creation called Earth and its inexplicable inequalities, we in the 1970's are superciliously trying to fashion an equal world, hopefully with enough food for all . . .

Food is one of the most complex economic, political and moral problems of our times. Despite a great deal of discussion and debate, particularly in the past four years, the underlying issues are still very confused and different groups of people in different parts of the world continue to look at the food problem from their own particular angle. The food situation itself and forecasts about its future are clouded by so many imponderables that predictions swing from deep pessimism to cautious optimism. International discussions about environment, population, food, habitat and water are all part of a sudden realization that without a major restructuring of relationships and concepts, the world simply cannot continue the patterns of production and distribution of the past 25 years for the rest of this century.

Similarly, the search for solutions to the food problem quickly runs into deep moral and political dilemmas which go far beyond the problem of food. Will the rich nations of the world continue to treat the world as a vast market or is there any hope of its evolution into a genuine international community? Is there any common ground between self-interest and the moral imperatives of feeding the whole of mankind? Is it possible for developing countries to achieve, within a system based on freedom of ownership, mobility and consumption, a minimum of equality to secure everyone's basic needs of food, clothing, shelter, medicine and education? . . .

The general objective of The World Food Conference of 1976 was to broaden and intensify the involvement of scientists and educators in solving world food needs through concerted efforts among universities, research organizations, extension service and their many disciplines. The World Food Conference [sponsored by Iowa State University's World Food Institute] attempted to meet that objective by bringing face to face hundreds of specialists . . . [including] internationally renowned nutritionists, economists, sociologists, animal scientists, food technologists, plant scientists, soil scientists, agricultural engineers, veterinarians and others . . . Publication of these Proceedings provides a record of the conference.

[Excerpted from the book.]

WORKSHOP ON AGRICULTURAL AND RURAL DATA: IMPROVEMENT IN CONCEPT AND OPERATION

The data systems used by agricultural economists have been, at times, the envy of the economics profession. But a recent workshop sponsored by the American Agricultural Economics Association and USDA's Agricultural Marketing Service, Statistical Reporting Service, and Economic Research Service was dedicated to the proposition that there is room for, and need of, considerable improvement. The following comments on the workshop, held May 4-6 in Rosslyn, Va., are excerpted from the remarks of the four rapporteurs.

Price Reporting

Concern about price reporting, according to rapporteur Milt Hallberg, was directed exclusively to AMS market news and SRS price reporting systems. The conceptual base of these price series was reviewed. The intent was to identify weak links in the price reporting systems and to establish priorities.

Market prices serve three major functions: allocation of scarce resources in the production and distribution of goods and services; distribution of economic rewards among people, places, functions, and time; and equilibration of supply and demand. Prices aid the understanding of the marketing system, and the judgment of how well it performs. AMS market news prices were found most useful as a guide to the short-run allocative decisions of firms. SRS prices were seen as helping firms make longrun allocative decisions and, perhaps more importantly, aiding in the analysis of a market's performance.

Economic agents must discover the equilibrium prices formed from

interaction of supply and demand before these prices can be used in the allocative process. Buyer and seller interaction, often subtle and complex, reflects uncertainty and randomness, which makes the process of price discovery imperfect and subject to rigidities. It can and does take many forms depending on the structural characteristics of the market or firm behavioral patterns. This in turn affects the quality and usefulness of data available for collection by USDA as well as the *need* for data of the two different types considered.

Session participants considered the emerging market structure of, and the alternative price discovery processes in use by, the agricultural industries and the resultant impact on the AMS and SRS price series. They also considered several technical problems associated with collecting and disseminating these data.

Capacity of Food and Fiber System

What is capacity? How is the concept being used? What are some of the methods by which it is derived? How can it be applied to the agricultural sector and of what use (if any) is it there? These are the four questions addressed, according to rapporteur Heinz Spielmann, by the three papers on agricultural capacity.

Existing capacity concepts in the agricultural sector relate mainly to market equilibrium. In the nonagricultural sector, the concept is differentiated into engineering capacity and economic capacity. No time series of capacity measurement exists in the agricultural sector, but several exist in the nonagricultural sector. The most important nonagricultural ones are provided by: The Federal Reserve Board, the Bureau of Economic Analysis of the Commerce Department, McGraw-Hill, and the Wharton School of the University of Pennsylvania. Capacity data are widely used by economists, industry analysts, banks, management, and by government decisionmakers.

Authors directed their attention to agricultural capacity measurement. Penn argued that capacity is a shortrun measure which, over the long run, indicates the efficiency with which fixed factors are used. Weeks saw capacity utilization measures as indicators of bottlenecks. Investment and output plans, and preferred operating rates expressed by farmers, may be established through capacity utilization measurements. Penson and Kibler recognized the whole food and fiber system, going beyond the narrower concept of the farm sector alone.

Some factors were discussed which affect capacity measurement differently in the agricultural than in the non-agricultural sector. Because of these factors, a useful agricultural capacity measure may be more difficult to conceptualize than those currently in use for the nonagricultural sector.

Discussants' remarks and audience responses were almost without exception rather pessimistic about the concept of capacity measurement and capacity utilization in the agricultural sector. The objections dealt mainly with the efficiency and applicability of capacity measurement, and the degree to which it could improve, or fail to improve, our existing behavioral knowledge of the agricultural sector.

Data for Indicators of Well-Being for People Engaged in Farming

"Personal income" and "wealth" were proposed, according to rapporteur Norman Whittlesey, as a measure of well-being for "people engaged in farming" by the committee assigned to the working paper for this session. The farm family household was deemed the primary unit of observation. The use of this unit would be a distinct departure from current methods which use the farm as a unit of observation.

Personal income was defined as operator's surplus accruing to the farm operator household from farm and nonfarm businesses; wages and salaries, rents, interest, and dividends; and public and private transfers less contributions to social insurance. In the proposed household wealth account, the major contribution of the new data series would involve data availability, particularly nonfarm assets. The wealth account would allow, and advocate, the use of capital gains as part of the well-being measurement. No index was suggested as a means of using the income and wealth accounts to consistently measure well-being in agriculture. The committee recommended that the responsibility for collecting information be assigned to the Bureau of Census or the Statistical Reporting Service.

During the discussion, the consensus seemed to be that improved income and wealth information was needed to make better policy decisions. Such new information should be added to rather than replacing current data series.

It may be wrong, some suggested, to focus on the farm operator household for creating a new survey population. Problem households in agricul- might be more easily identified through other means than those suggested in the working paper. Other questions arose: How would income problems related to corporate agriculture, partnerships, hired workers, and so on, be identified and dealt with? Could such data collection be justified for only the farm sector or should similar data be collected for all sectors of our economy?

In view of its potential costs, people questioned the value of added information about well being in agriculture, asking for what kinds of policy decisions this information would be applicable. These questions were not answered; it seemed to be implicitly understood by most people that the answers would evolve naturally following collection of the necessary information, a dubious belief indeed.

Greater effort should be given to the justification of such information before it is collected. How will it be used? Who will benefit? Will benefits to persons providing the information at least equal their cost in providing it? Could the costs involved be justified to the Office of Management and Budget or to the Congress?

Farm and Rural Employment Data

Farm employment has three aspects, according to rapporteur Keith Bryant, about which information might be sought: (a) who controls the nonlabor farm resources with which and on which farm laborers work; (b) who makes the managerial decisions; and (c) who performs the labor; what kind of labor; how much; at what wage rate; and with what accompanying fringe benefits. The taskforce on farm employment attempted to improve the definition of the last aspect. Much emphasis was placed on the who, what, and when; some attention was paid to

fringe benefits; and no attention was paid to wage rates.

The task force used two criteria to think through the recommendations: (a) farm employment should be measured in a way that is comparable and compatible with nonagricultural labor data sources; (b) the measurements should retain what is unique and special to agriculture, including presence of seasonal and migratory workers and family labor, and the practice of multiple-job holding. It was recognized that more resources will not be devoted to farm employment data collection.

The Standard Industrial Clarification definitions of agricultural industries and the Standard Occupational Classification treatment of farm occupations were recommended. But, for SRS quarterly purposes, a more abbreviated set of categories would be required. "Farm operator" was singled out as a no longer useful category because of technological and entrepreneurial evolution. Nor is there an analogous concept in other industries.

The taskforce recommended the concept "self-employed in farming," which could encompass partnerships as well as joint ownership and/or management arrangements. This recommendation was the most radical. It was criticized as requiring presence on the farm; thus it excludes the absentee self-employed. It does not improve the concept of unpaid family worker. Some session participants believed that a definition should speak to the issue of resource ownership and managerial activity as well as employment status, and that the self-employed concept spoke only to the matter of employment. Distinctions among self-employed workers, unpaid workers, and hired workers were questioned, given that there are tax incentives to paying one's family cash wages.

Other recommendations included: collect monthly employment data on the SRS quarterly survey; collect data on labor turnover; collect data on employment costs and fringe benefits; and publish more of the data that is collected. Session participants also raised issues not treated in the report, including underemployment, migratory workers, and wage rates.

Underemployment did represent a subject in the rural employment data session and it provided a bridge between that session and the session on farm employment. The concept came up in two contexts: as a hypothesis that rural people are more burdened by underemployment than urban people; and as a guide to the allocation of Federal program funds. Measuring underemployment has not progressed much past the work of Glasgow in the early sixties. Part of the problem may be that the phenomenon is an attribute of people, yet, its policy applications are concerned with place.

Authors of the rural employment paper created a general typology by which data deficiencies for social research and policy needs could be identified and worked on. They presented results of a poll of professionals in the field of rural development as to their employment data needs and their perceptions of data deficiencies. A valuable bibliography of employment data sources was included.

The authors recommended: (a) publication of data at the most detailed geographical level possible, or more rural-oriented aggregation of geographic detail, (b) publication of public use tapes of economic censuses with fine-grain SIC code and geographic detail and (c) expansion of the CPS by oversampling rural people to gain accuracy for the nonmetro part. Finally, the authors pleaded for more communication between users and suppliers.

The people attending the employment session were regional, health, labor, and natural resource economists, persons involved in public finance and in human capital development, community developers, and others. Why did the planning committee expect a single session to serve these diverse interests? Their commonality consists of two aspects: that we grouped them together for the workshop, and that they use data supplied by agencies over which USDA has little or no control. Neither SRS nor persons taking the Census of Agriculture collect the data. The data collection is done in other agencies, who dance to different, typically urban tunes. It is past the time that we can put all of us not centrally concerned with commercial agriculture into an undigestible lump. In future, workshops must have smaller groups of specialists so that we can discuss directly relevant concepts and data needs.

We are data users, for the most part. Relevant data suppliers are not in, or influenced much by, the AAEA and USDA. We need better representation on the advisory committees to the Bureau of Economic Analysis, the Bureau of Labor Statistics, the population census, and the economic censuses other than agriculture. Here, the AAEA might help by working through the Federal Statistics Users Advisory Conference. It is time for there to be a statistics review editor for the *American Journal of Agricultural Economics*. That persons's task would be to commission timely reviews of new data series, or old data series being revised or in need of revisions.

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U.S. AGRICULTURE AND TRADE ADJUSTMENT ASSISTANCE

The Trade Act of 1974 (hereafter cited as TA-74) represents a significant policy change for agriculture, one with which agricultural economists and others working in agriculture should be familiar. Besides giving the President certain negotiating authority over trade matters, as do all trade bills, TA-74 extends and liberalizes the "adjustment assistance" provisions of the Trade Expansion Act of 1962 (*2*, p. 5).* These provisions were considered a radical innovation in the 1962 Trade Act since no precedent existed either in the United States or abroad for compensatory adjustment payments

*Italicized numbers in parentheses refer to terms in References at the end of this note.

to domestic interests injured by international merchandise movements. Further, for the first time in U.S. tariff history, TA-74 extends adjustment benefits to farm owners/operators, farmworkers, and farming communities (7, p. 145).

ELIGIBILITY AND BENEFITS

Workers

Under Section 221 of TA-74, a group of workers files a petition of eligibility with the U.S. Secretary of Labor. The Secretary certifies a group of workers as eligible if he finds that:

(1) A significant number or proportion of workers in a firm have been or are threatened to be totally or partially laid off,
(2) Sales or production of the firm have decreased, and
(3) Increases in imports of articles like or directly competitive with articles produced by the workers' firm contributed importantly to the separation or threat of layoff of the workers, and to the decline in sales or production.

Worker benefits include an allowance equal to 70 percent of weekly earnings prior to layoff, for a period of up to 52 weeks. Other benefits provided are counseling, testing, placement services, training, job search allowances, and relocation allowances.

Firms

For firms, the injury test is virtually identical to that required of workers. Petitions are filed with the Secretary of Commerce. A firm must then file a proposal for adjustment which:

(1) Will contribute to the adjustment of the firm,
(2) Gives consideration to workers of the firm, and
(3) Demonstrates that the firm will use its own resources, where possible, for its economic development, and that the firm has no reasonable access to private financing (Sec. 251 and 252, P.L. 93-618).

Two types of assistance are available to eligible firms. First, the U.S. Government will pay up to 75 percent of the cost of technical assistance of consultants who develop, prepare, and assist in implementing an "economic adjustment proposal" for the firm. Second, loans and loan guarantees are available for working capital, modernization, construction, and acquisition of land, plant, buildings, and machinery, for periods up to 25 years.

Communities

A new program established by TA-74 is that of community adjustment assistance. By creating new industry and job opportunities, this program is intended to help restore the economic viability of areas adversely affected by increased imports. Under the program, local governmental units petition the Secretary of Commerce, and eligible communities may receive development assistance including technical assistance, improvement of public works, and measures designed to attract new investment.

IMPLICATIONS FOR AGRICULTURE

Many barriers and special problems relating to agriculture are being addressed at the multilateral trade negotiations in Geneva. There are many U.S. commodities which are protected from foreign competition. Among the better known protective measures are the voluntary export restraints on wool, beef, veal, and mutton, and the quotas on certain dairy products, cotton, and sugar. On the other hand, U.S. agricultural exports are inhibited by restrictions imposed against them by our trading partners. Examples include the variable levies of the European Community Common Agricultural Policy on wheat and grain, and the sudden suspension of the quota on beef imports to Japan in February 1975. Accordingly, adjustments in U.S. agricultural production and trade may be expected over the next decade (*4*). While there will be gains to some sectors of agriculture, other sectors may be injured. There is likely to be a move away from production of protected agricultural products towards those where the United States has a comparative advantage.

Johnson has ranked U.S. agricultural commodities by their level of comparative advantage at prevailing world prices (*3*). He finds that the United States possesses a comparative advantage in the production of feed grains, soybeans, wheat, tobacco, and poultry. He sees an uncertain situation for rice, cotton, flaxseed, pork, beef, and oats, and a comparative disadvantage in manufactured dairy products, sugar, wool, sheepmeat, and peanuts. Johnson estimates that complete displacement of sugar and peanut production, and elimination of import restrictions on dairy products and cotton would result in a total loss of about 7 percent of farm labor and 8 percent of farmland (*5*). However, if United States concessions were accompanied by trade concessions from other countries, he calculates that the resultant increased use of land could easily reach 20 million acres.

Even so, because of resource inflexibility, it is unlikely that resources will flow readily from the injured sectors to those that benefit from freer trade. Such adjustments will not be without considerable impact on many individual farm operators and farmworkers. As Schmitz and Seckler note of past adjustments, ". . . we tend to forget the painful process that accompanied the transition from a rural to urban society. We have forgotten that for many people the transition was involuntary; that many people have been forced off the farm only into an economic and social limbo . . ." (*6*).

With passage of TA-74, government assistance is promised in the transition either out of agriculture or into another line of agricultural production. This represents a rather remarkable, albeit unintentional, change affecting U.S. agricultural policy. Unlike earlier policies which restrained adjustment by providing price supports, production controls, and import restraints to protect domestic producers, the adjustment assistance provisions of TA-74 assure that at least persons and firms in that sector of agriculture affected by increased import competition will not be inhibited in moving from previously protected production into other agricultural or nonagricultural occupations. However, the adjustment assistance provisions do not compensate farmowners for a decline in the price of some land that would result from tariff removal.

IMPLICATIONS

Agricultural economics departments are likely to receive many

requests from farmers to assist in the preparation of a farm firm's "economic adjustment proposal." Farm management personnel may find it useful to construct a flexible computer model of a farm which shows its expenditure and receipt streams, capital requirements, and growth path over, for example, a 5-year period. Such a model would be particularly useful if farms affected in the region are fairly homogeneous.

Extension workers should be aware of the law so they may advise farmers of their prospective eligibility, guide them through the adjustment assistance maze, and counsel them as to their options in changing the enterprise mix or seeking urban employment.

Community and human resource development specialists may find their services in demand by some rural regions which want to take advantage of the community adjustment provisions of TA-74.

Costs

Researchers have not estimated the costs of the program in the agricultural sector. These will depend on the magnitude of adjustment which, in turn, depends on such variables as the extent and staging of tariff cuts or quota liberalization, relative exchange rate movements, inflation rates in the United States and abroad, relative changes in productivity, and changes in real income here and in countries we trade with. Bale and Mutti have developed a model to make such estimations and have applied it to the U.S. footwear industry (*1*). Such calculations have yet to be made for agriculture.

Conflicts of Interest

Finally, most significant changes considered by Government involve conflicts of interest. Many Pareto-superior moves entail gains and losses which are equivalent to redistributions of income. Welfare economists use the compensation principle to ask simply: "Is it possible for the gainers to compensate losers so that everyone is at least as well off as before the move?" In practice, such compensation is seldom made. The adjustment assistance provisions of TA-74 may be regarded as an example of the gainers (consumers using Government as an intermediary) actually compensating the losers in a Pareto-superior move toward free trade. Whether the losers are overcompensated or undercompensated is a question for later research. For agriculture a point of further significance is that the policy stimulates rational adjustment rather than inhibiting it.

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CURRENT CONDITIONS IN AGRICULTURAL TRUCKING

Unmanufactured agricultural commodities trucked interstate are exempt from economic regulation by the Interstate Commerce Commission (ICC); thus, data on this trucking are not usually available from them. During 1976, however, the Commission conducted a year-long study of the "empty backhaul" problem, one that affects agricultural and other commodities shipped by truck (*4*).[1] Interstate highway locations were selected for manageability. They tended to concentrate the survey more heavily on interstate trucking. A total of 13,165 randomly selected trucks, 3-axles or larger, were stopped by cooperating State highway officers at 439 check points on 221 segments of the Interstate Highway System. ICC employees interviewed the drivers about their origins, destinations, operating authorities, commodities on board or usually carried, and reasons for driving empty if not loaded. The trucks were classified into three groups: trucks operated for ICC authorized carriers, trucks that are "exempt" (that is, insofar as ICC authorities are concerned but including those with intrastate operating authorities only), and trucks that are private (that is, operated by firms not engaged primarily in transport, to haul their own products).

The intent here is based on the ICC study, to describe current conditions in agricultural and other rural trucking and to analyze implications of the findings for proposed regulatory changes.

CURRENT CONDITIONS

Agricultural commodities were the cargoes for 2,851 trucks, 28.1 percent of the 10,133 loaded trucks observed (*4*, table VIII, p. 25). Exempt agricultural commodities constituted the loads for 1,303 trucks of which 351 were operated by ICC-authorized truckers, 697 by exempt truckers, and 253 by private truckers.[2] Regulated agricultural commodities constituted loads for 1,548 trucks of which 832 operated under ICC authority, 85 were exempt (pre-

[1] Italicized numbers in parentheses refer to items in References at the end of this note.

[2] The ICC report does not provide information about the "private" trucks reported in this category, but it is not likely that many were operated by the shippers of unmanufactured agricultural commodities. "Private" truckers of the regulated commodities (for example, General Mills) often haul exempt commodities on a for-hire basis in competition with regulated and exempt truckers, both as backhaul traffic and in seasons of slack traffic for the primary shipping firms (*3*).

sumably moving intrastate only), and 622 were privately owned. For all commodities, private trucks accounted for 31.3 percent of all loaded and partly loaded trucks. Thus, relatively more private trucks carried regulated agricultural and other commodities than exempt commodities.

Of 1,041 loaded trucks classified as operated by for-hire truckers without ICC authority, 67 percent contained exempt agricultural commodities. For all exempt trucks, 21.2 percent of their miles were empty, compared with 16.2 percent for ICC authorized and 27.3 percent for privately operated trucks (*4*, table 1, p. 6). Refrigerated trucks are also important to agriculture. Of 2,164 such trucks of all carrier types, 14.8 percent of the miles were empty.

ICC employees analyzed all empty trucks for type of equipment, time, location, and direction of movement. All pairs of empty trucks with compatible equipment that were moving in opposite directions on given highway segments within 3 hours of each other were labeled as "empty-meeting-empty" pairs. They represent a potential for reducing empty movements. There were fewer pairs of empty ICC-exempt and private-exempt trucks but more pairs of empty exempt-exempt trucks than were to be expected, based on the relevant numbers of empty trucks observed (computed from *4*, fig. K, p. 34).

Types of pairs	*Actual pairs*	*Expected pairs*
ICC-exempt	14	21.4
Private-exempt	16	23.4
Exempt-exempt	7	4.6

The pairings by types of carriers while not statistically significant, are consistent with the often stated but so far untested hypothesis that the lack of ICC authority for the exempt trucks (which limits them to "thin" markets in their search for backhaul loads) do result in relatively more empty movements by exempt trucks.[3]

An analysis of 652 trucks in a 1-in-20 subsample showed the number of trucks originating at places by population size and the percentage empty.[4] A second distribution was by size of destination places (*4*, table XI, p. 37). Of the trucks destined for small places, considerably more of them (48 percent) were running empty than were those originating in small places (27 percent). Such a pattern was expected since bulky, low-valued, exempt agricultural, forest, and mine products move heavily from rural areas (smaller communities) toward concentrations of population (larger communities). Also, many of the truckers hauling exempt agricultural commodities as well as private truckers hauling regulated agricultural commodities have no ICC operating authorities for returning regulated commodities to rural areas. However, the difference in the percentages was not statistically significant.

Based on the subsample of 652 trucks, empty trips were only half as long as loaded trips. Many drivers reported that they were driving from unloading points to other points where loads were available for return trips. Thus, the "empty backhaul" problem is, in many instances, an "empty segment" problem.

IMPLICATIONS FOR PROPOSED REGULATORY

Some persons claim that deregulation of all trucking would result in more for-hire trucking of the currently regulated commodities with higher qualities and lower costs of the service. The statistically significant lesser role of private trucking in the exempt sector reflected by the ICC data is consistent with what these persons claim would result from a move toward less regulation. However, other factors contribute to that result for agricultural traffic. Perishable crops are shipped from many small shipping points on a highly seasonal basis.[5] Such shipping patterns may not permit organization of efficient private trucking, and a system of truck brokering has developed in many areas to bring for-hire truckers and exempt commodity shippers together (*2*).

Nonetheless, these claims are consistent both with logic and evidence of impacts accruing from past changes in regulations. There are costs involved in regulatory processes, and operating authorities for truckers are constrained by commodity, route, and equipment specifications such that flexible services may not be as readily available in a regulated market.

Supreme Court decisions in the fifties removed regulation for fresh and frozen dressed poultry and frozen fruits and vegetables. "Before" and "after" studies found that, following the decisions, average rates decreased 19 percent or more, fewer shippers hauled their own products, and more shippers claimed that the quality of services of for-hire truckers improved than claimed that it declined (*7* and *8*).

In 1958, the Congress removed the Court-mandated exemption on frozen fruits and vegetables. Another "before" and "after" study found that tendencies this time went contrary to those observed at the earlier period. That is, more rates increased than decreased, more shippers resorted to private trucking, and many shippers found services less satisfactory (*9*).

The ICC study does not provide any proof as to the impacts that change in regulatory status might generate for empty/loaded truck miles and/or favorable rates to and from rural areas. Some members of the ICC and regulated truckers, among others, have argued that one-time measures of empty/loaded ratios cannot prove or disprove a disadvantage for truckers not holding ICC authorities. They also argue that any change in regulatory status to favor the "disadvantaged" truckers likely would shift empty miles from this group of truckers to the other, with only nominal or no reduction of overall empty/loaded ratios. They attribute this view to basic traffic imbalances in the nation.

The first argument seems valid. The second argument overlooks the possible modifications of existing traffic patterns that might accrue

[3] The observed number of empty exempt trucks involved in these pairings is small (44 total), but it is unlikely that a larger sampling of truck movements will become available anytime soon. Such surveys are expensive and require intergovernmental cooperation.

[4] ICC employees plan to analyze additional subsamples to develop more details on truck movements and to yield more precision for estimates.

[5] However, livestock for slaughter, live broilers, eggs, milk, and dressed poultry do not have strong seasonal patterns of movement.

from reorganizations of truck routes and schedules.[6] It also overlooks a strong theoretical basis for believing that deregulated trucking would generate favorable rates on traffic moving in the directions that more empty trucks are moving (*1*). If current rate structures are contrary to those expected in an unregulated setting, then deregulation would tend to spur nonagricultural development of rural areas, which would affect traffic balances.

From the limited evidence available on current rate structures, regulated commodities generate both higher revenues and higher costs per vehicle mile than do the exempt commodities (*6*), which lends some support to the view that current rate structures, are contrary to what one might expect with unregulated trucking.[7] Nearly all traffic moving to rural areas likely is regulated when carried by for-hire trucks.

Some regulated truckers claim that deregulation would deprive rural communities of trucking services on regulated commodities moving to and from these areas. The ICC data do not support this claim. Much of the regulated traffic moving from rural communities is regulated agricultural commodities, and the ICC data show that private trucking is currently important in these movements. Exempt commodities do move from rural areas in heavy volumes. Various studies show that unregulated trucking provides usually adequate quantities and qualities of services at rates roughly in accord with the costs of trucking in the specific corridors (that is, with congestion and backhaul opportunities accounted for).[8]

As to movements of regulated commodities to rural areas, analysis of all of the ICC data may show that the ratios of empty/loaded trucks moving to and from smaller communities support the view that incentives exist for unregulated trucking to provide adequate services at reasonable rates for such movements. Nonetheless, the highly seasonal nature of the movement of some exempt agricultural commodities from rural areas could result in reversals of the directions of majority traffic flows during the year. Such changes would be expected to generate wide swings in applicable rates. Unfortunately, the ICC sample produced too few observations on exempt commodity and unregulated trucker movements to provide reasonably precise estimates of corridor, seasonal, and commodity movements of the nature required to analyze this phenomenon in detail for rural areas.

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[6] Some reorganizations have already occurred through mergers and acquisitions of regulated truckers. In other instances, traffic patterns are balanced, or more nearly balanced, by hauling exempt commodities on the "backhauls."

[7] These measurements were for "small" carriers of the sizes likely dominant in serving rural communities.

[8] For a concise summary of several studies, see (*5*).

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A NOTE ON "EFFECT OF SIZE OF THE INPUT-OUTPUT MODEL ON THE RESULTS OF AN IMPACT ANALYSIS"

In an article published previously in this journal (*1*), Doeksen and Little used four empirical models to show that the output multiplier of a specific industry alters very little if the remaining industries of an input-output model are aggregated into a single composite sector.[1] My purpose is to show that the conclusion reached empirically by Doeksen and Little has been proved by others (*2, 3*) to be true in principle.

Aggregation of an $n \times n$ matrix of technical coefficients, A, into an $m \times m$ matrix of aggregate technical coefficients, $\bar{A}$, is given by the following operation (*2*):

$$\bar{A} = TAX_o^D \, T' \, (TX_o^D T')^{-1} \quad \ldots.(1)$$

where X_o^D is a diagonal matrix, the elements of which are the gross outputs of the n industries in the base period, and T is an $m \times n$ aggregation operator, each row of which contains at least one unit and each column of which contains exactly one unit while the remaining elements are zero.

Hence, if an $n \times n$ matrix of technical coefficients is aggregated into, for example a 4×4 matrix of aggregate technical coefficients in which the first three industries remain distinct and the remainder are aggregated into a single sector, T takes the form:

[1] Italicized numbers in parentheses refer to items in References at the end of this note.

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & \dots & 0 \\ 0 & 1 & 0 & 0 & 0 & \dots & 0 \\ 0 & 0 & 1 & 0 & 0 & \dots & 0 \\ 0 & 0 & 0 & 1 & 1 & \dots & 1 \end{bmatrix} \quad \dots (2)$$

Output multipliers obtained from the original model are given by

$$m' = i_n' (I-A)^{-1} \quad \dots (3)$$

and from the aggregated model by

$$\overline{m}' = i_m' (I-\bar{A})^{-1} \quad \dots (4)$$

where i_n' is a row vector of n units and i_m' is a row vector of m units.

Since $i_n' = i_m' T$ and $(I-\bar{A})^{-1} T$ is $(I-\bar{A})^{-1}$ with the last column repeated n-3 times, the difference between output multipliers obtained from the original model and those obtained from the aggregated model form the elements of the row vector:

$$i_m' T(I-A)^{-1} - i_m' (I-\bar{A})^{-1} T \dots (5)$$

but only the first three elements are of interest.

Expression (5) can be expanded as:

$$i_m' T(I + A + A^2 + \dots)$$

$$- i_m (I + \bar{A} + \bar{A}^2 + \dots) T$$

$$= i_m' \left\{ (TA - \bar{A}T) + (TA^2 + \bar{A}^2 T) + \dots \right\} \quad \dots (6)$$

Morimoto (*3*) has pointed out that the columns of TA and $\bar{A}$T which correspond to the industries not aggregated are equal. Hence, the difference between the multipliers of these industries, obtained from the original and aggregated models, is of the second order only.

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In Earlier Issues

Parity prices have been an integral part of agricultural policy of the United States since 1933. Action programs that have had a material effect on the economic situation of agriculture have been based on or related to parity prices. These programs include such things as price supports, price ceilings, and marketing agreements and orders. Parity prices in themselves are merely measuring devices or yardsticks; it is only when action programs based on parity prices are in operation that prices received by farmers are appreciably affected by them . . .

Parity income has not been used as a basis for any agricultural program. . . . Parity income . . . is the per capita net income to persons on farms from farming that bears the same relationship to per capita income of persons not on farms as prevailed in 1910-14. This definition was more or less tailored to fit the available statistics. It will be noted that the nonfarm income of farm people is allocated by this definition to the nonfarm population. It seems fair to say that practically no one has been completely satisfied with this definition.

C. Kyle Randall
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